USING VISUAL METAPHOR AS A NAVIGATION AID IN HYPERTEXT

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IN HYPERTEXT

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CHAPTER 1: INTRODUCTION

The advent of computer technology and sophisticated computer programs allows technical communicators to store substantial amounts of information in databases. To take advantage of this technology, technical communicators have started to shift from the traditional approach of delivering information to readers on paper to the more innovative approach of displaying information on the screen, or online. This approach has significant importance for presenting technical information because it has the potential to allow readers to browse large databases conveniently and to access related information quickly (Rubens 1991).

A common way to present online information is to connect pieces of information together in a database by using hypertext links (Bernstein 1991). With these links, readers can go from one piece of information to another, or from one database to another, to search for information they need. Hypertext links make it possible for technical writers to present large amounts of related information. For example, an online system may provide tourists with information about a city. It may contain information about places such as shopping centers, restaurants, cinemas, and museums. For instance, users may use the system to find a cinema to watch a movie or an Italian restaurant to have dinner.

Hypertext allows technical communicators to link related information together so that users can choose their own paths. Figure 1 shows a model of how a sample hypertext program presents information.

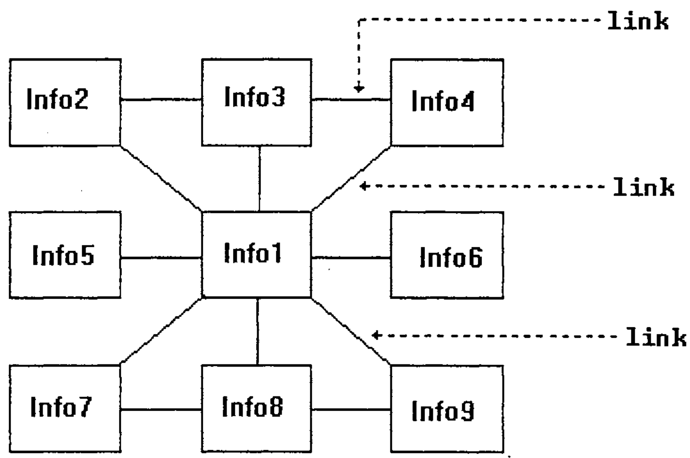


Figure 1. Model of a Hypertext Program

In Figure 1, the lines linking the pieces of information together represent hypertext links. Info1 is linked to all other pieces of information, and Info2 is linked to Info3, which, in turn, is linked to Info4. The model in Figure 1 is a simplified version of a hypertext program. If appropriate, any piece of information may link to any other piece. Figure 1 does not show all the possible links because it would be too cluttered to show all the links.

Users can choose their own paths, or links, to search for information they need. A path refers to a series of links users select to locate information. These links allow users to access information in a hypertext system in a random manner. "Random" means that users choose their own paths, and they do not necessarily go through all the information the hypertext author presents in the database. In fact, a hypertext program contains a large amount of information, and the hypertext author assumes that users will choose only the information relevant to their search preferences.

As explained in the next section, the idea of presenting information in a database via links is not new. It originated in the 1940s when a need for accessing large amounts of information arose.

Brief History of Hypertext

Many researchers (e.g., McKnight, et al. 1991; Conklin 1987) have identified Vannevar Bush, the first director of America's Office of Scientific Research and Development during the Roosevelt administration, as the founding father of hypertext. In his oft-quoted article "As we may think" published in *Atlantic Monthly* in 1945, Bush noted the problems of accessing growing amounts of information:

> There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers -- conclusions which he cannot find time to grasp, much less to remember, as they appear. Yet specialization becomes increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial. (101)

Trying to meet the need for knowledge in the information age, Bush introduced a machine for browsing and making notes in an extensive online text and graphics system. This machine, called "memex," would allow users to search for needed information quickly. Such a device would be based on associative indexing. The idea allowed users to access from one piece of information to any other piece. This system would take advantage of the associative nature of human thinking. However, the information technology of Bush's time was not sufficient to implement his idea.

Based on Bush's idea of "memex," Doug Engelbart (1963) has been developing his hypertext system since the early 1960s. Engelbart remarked that the user and the computer were dynamically changing components in a symbiosis that had the effect of "amplifying" the native intelligence of the user. In 1968, he developed and implemented a system that contained information, such as documents, memos, notes, reports, bibliography, and reference notes. This system provided an environment in which computer-supported collaborative work could take place.

While Engelbart was developing his hypertext system, Nelson (1987) was also working on a hypertext system that created a unified literary environment on a global scale. He named his project "Xanadu," after the magic place of literary memory in Samuel Taylor Coleridge's poem "Kubla Khan." His project was aimed at a structure in which the whole literature of the world is linked -- "a universal instantaneous hypertext publishing network" (Nelson 1987). Nelson describes his objectives as follows:

> Under guiding ideas which are not technical but literary, we are implementing a system for storage and retrieval of linked and windowing text. The document, our fundamental unit, can have windows to any other documents. The evolving corpus is continually expandable without fundamental change. (25)

The long-term goal of Nelson's project was to enhance the revolutionary process of placing the entire world's literature in an electronic medium. His project attempted to provide an environment in which computer-supported collaborative work could take place. As we can see, these early advocates of hypertext all noticed the increasing amount of information and decided to seek a means to develop a system to cope with this problem. Bush only brought up the idea, but Engelbart and Nelson, with the aid of more advanced technology, implemented his idea. They all have the same goal: using the idea of hypertext to develop a system to encompass an encyclopedia of information so that users can quickly and easily access needed information.

Definitions of Hypertext

Many hypertext researchers (e.g., Conklin 1987; Tripp and Roby 1990; Tsai 1988-89) refer to hypertext as "nonlinear text." Ted Nelson (1987) defines hypertext as "a dynamic display of non-linear text." "Non-linear text" refers to text that lacks the structure of a book. For instance, a book has conventional components such as the table of contents, preface, and overview. Most importantly, all the pages are sequentially numbered, giving the "linear" structure of a book. A hypertext program presents screenfuls of information, and they are not numbered, giving the impression that the author presents information "randomly."

Echoing Nelson, McKnight et al. (1991) define hypertext as "dynamic documentation," indicating that hypertext consists of nodes and links between them. A node represents a piece or pieces of information, and a link enables users to go from one node to another. Conklin (1987) considers these machine-supported links the essential feature of hypertext systems.

In addition to defining hypertext as non-linear text, Conklin (1987) offers another definition. He considers hypertext to be a computer-based medium for thinking and communicating. Hypertext is a representation scheme, a kind of semantic network that mixes informal textual material with formal and mechanized operations and processes. He also points out that hypertext is an interface modality that features "control buttons" that can be arbitrarily embedded within the content material by the user.

Extending the concept of non-linear text, Yankelovich et al. (1989) defines hypertext as "nonsequential writing and reading. Both an author's tool and a reader's medium, a hypertext document system allows authors or groups of authors to link information together, create paths through a corpus of related material, annotate existing text, and create notes that point the reader to either bibliographic data or the body of the referenced text." The researcher considers hypertext not only a tool for writers but also a tool for users.

In this dissertation, I adopt the definition that hypertext is a program, or database, consisting of pieces of information connected via electronic links.

Problem Statement

Because a hypertext system provides users with options to access information, users can locate information via paths of their choice. Because of this search method, users often encounter the problem of being disoriented or becoming "lost in hyperspace" (Conklin 1987; Edwards and Hardman 1989; Grice et al. 1991). For example, in a hypertext environment, users may fail to locate a piece of information they have read on a previous screen.

Hypertext can enhance the effectiveness and usability of systems, but may present a usability problem of its own, particularly in terms of navigation (Smith and Wilson 1993). Also, as data structures increase in dimension and complexity, users will be more likely to become disoriented and fail to find desired information or facilities (Aksyn 1988; Carr 1988; Hammond and Allinson 1988).

Navigation is the single greatest difficulty for hypertext users (McKnight et al. 1991). They become lost because hypertext lacks the "linear" structure of paper. With paper documents, readers can identify the location of certain information in the body of the text. The ordering of topics and points and the inclusion of various devices such as overviews and summaries are taken for granted in books and papers, but are not noticeable in hypertext and thus the overall structure is quite different (Charney 1987).

Researchers have suggested different ways to solve the disorientation problem. For example, Grice et al. (1991) have suggested that technical communicators limit the number of information nodes in a hypertext program so that users would be less likely to become disoriented. To give users an idea of the structure of a hypertext program, Utting et al. (1989) have suggested that technical communicators use graphics to represent the information nodes of a hypertext program. Other researchers (Rizk et al. 1990; McKnight et al. 1991) have suggested using metaphor, e.g., the desktop metaphor, to improve the usability of a program. The desktop metaphor uses small pictures, or icons, on the computer screen to represent various functions of a program. However, no researcher has suggested using icons as a navigation aid to help users navigate in a hypertext program. Chapter 2: Literature Review discusses in detail previous attempts at solving the orientation problem and using metaphors in designing computer programs.

Suggested Solution

This study focused on examining the possibility of using visual metaphors to help users navigate in a hypertext program. In this study, I use "visual metaphor" to refer to small graphical representations, or icons, and "a hypertext program" to refer to a computer program that uses links to connect pieces of information. Using icons as a navigation aid in hypertext may be a viable solution to the navigation problem because technical communicators have used metaphor to design user-interface to help users use computer programs. The suggestion for using icons in hypertext as a solution to the disorientation problem is new because little research on using visual metaphor as navigation aid in hypertext is available, although other researchers (e.g., Benbasat et al. 1993; Lansdale et al. 1990) have examined using icons to help users find needed information in other environments, such as a menu-selection environment. Chapter 2: Literature Review gives more details on research on using icons to enhance the usability of computer programs. This study is unique because, unlike other researchers who studied the effectiveness of icons in the menu-driven environment, I conducted an empirical study in the hypertext environment so the results would be directly applicable to hypertext programs.

To investigate the possibility of using icons as a navigation aid in the hypertext environment, I attempted to answer this research question: Does a hypertext program using icons help users navigate more effectively than a hypertext program using words? I compared the effectiveness of icons to words because I intended to use words as a reference point. Icons would be effective if they helped subjects find information faster than words. Icons would not be effective if they failed to help subjects find information faster than words. The objective of this study was to examine the effectiveness of using icons in a hypertext program as a navigation aid.

The significance of this study is that it would provide a solution for technical communicators to the problem of disorientation in hypertext. Solving this problem would enhance the usability of a hypertext program and, more importantly, help hypertext users find needed information. Also, the findings would provide technical communicators with empirical evidence for using visual metaphor as a navigation aid in hypertext programs. Although computer systems and programs have used metaphor in enhancing their usability, using visual metaphor to improve navigation in hypertext has never been a research emphasis as the scarcity of research on visual metaphor and hypertext indicates.

Focus of the Study

In this research, I conducted an empirical experiment to investigate whether subjects using the icon version of a hypertext database program could search needed information faster than subjects using the word version of the same program. My methodology is unique because I conducted my study in the hypertext environment and therefore the results are directly applicable to hypertext programs. The database program I used for the experiment represented a shopping mall in which I had subjects locate certain stores. To determine which version was more effective in helping the subjects navigate in the mall, I measured the times the icon group and the word group took to complete the tasks and, via a t-test, compared their times to see which group completed the tasks significantly faster. Because I intended to measure the completion times of the icon group and the word group, the dependent variable was the times it took the two groups to complete the tasks. The two independent variables I used in the study were the familiarity with the icons used in the hypertext program I designed and the familiarity with using the hypertext program to find information. I chose these two variables because I intended to see if users could navigate more efficiently after they were familiar with the program and the icons used in it.

In terms of the two independent variables, I examined whether subjects using the icon version of a hypertext program could search information faster than subjects using the word version of the same program under these three conditions:

Condition 1: The subjects in the icon group were not familiar with the icons in the hypertext program I designed for this study.

Condition 2: The subjects in the icon group were familiar with using the hypertext program to locate information they needed. However, they were not familiar with the icons they needed to locate in the hypertext program.

Condition 3: The subjects in the icon group were familiar with the icons in the hypertext program and with using the program to locate needed information.

Condition 1 allowed me to examine whether icons were more effective than words in helping subjects navigate in a hypertext program when the subjects in the icon group were not familiar with the icons in the program initially. In other words, the subjects encountered the icons for the first time. The findings would be applicable to hypertext programs a person uses only one time or occasionally. Such programs could include online programs that help a user install or upgrade a piece of software.

Condition 2 allowed me to examine whether icons were more effective than words in helping users find information when they knew how to use the program. Users may not be able to take full advantage of icons if they spend mental resources on learning the hypertext program. Once they know how to use a program, they can focus on the task they intend to complete instead of learning how to use the tool. Therefore, condition 2 allows me to measure accurately the effect of icons on helping users navigate to locate information.

Condition 3 allowed me to examine if icons were more effective than words in helping subjects navigate in a hypertext program after they had known what the icons meant and how to use the hypertext program to find needed information. The result would be applicable to hypertext programs users need to use repeatedly. In Chapter 3:

Methodology, I give more details on how I conducted the empirical study under the three conditions.

The following chapters detail the disorientation problem in hypertext, describe the methodology I used to conduct the empirical study, report the research results, and interpret the results.

CHAPTER 2: LITERATURE REVIEW

This chapter examines previous research on the navigation problem hypertext users encounter and possible solutions to this problem. Most importantly, I will point out that we do not have empirical evidence that using icons can help users navigate in the hypertext environment, and my research attempts to provide such evidence.

Hypertext systems provide users with different links to access needed information. Because of this characteristic, users often encounter the problem of being disoriented or becoming lost in a hypertext document (Conklin 1987; Edwards and Hardman 1989; Grice et al. 1991; Yeo 1996). As data structures increase in dimension and complexity, users will be more likely to become disoriented and fail to find information they need (Hammond and Allinson 1988; Aksyn 1988).

Elm and Woods (1985) describe *disorientation* in terms of degradation of user performance rather than subjective feelings of being lost. They define getting lost as users not having a clear conception of their relationships with the system, or not knowing their present location in the system relevant to the display structure and finding it difficult to decide where to look next within the system. Similarly, Conklin (1987) uses *disorientation* to refer to the problem of knowing where users are in the hypertext system and how to get to another place that users know, or think, exists in the system. Following is my own example to illustrate the disorientation problem Elm and Woods (1985) and Conklin (1987) suggest. In a hypertext program representing a city, e.g., Los Angeles or New York City, users may have problems going from the original position, e.g., the main menu, to the current place e.g., a restaurant or a shopping center. The users may also have problems telling their current locations in relation to other places in the hypertext program; consequently, they have difficulty finding the next destination from their current positions. For example, users may not be able to go from the restaurant they have just found to a clothing store in the hypertext program.

An effective hypertext program should allow users to generate specific links as the task requires, to traverse or generate new routes as skillfully as familiar ones, and to develop a concept of "here" in relation to other places. Because hypertext lacks the organization printed documents have, technical communicators need to help users visualize how the information is linked together. In other words, the system needs to help users identify their locations in relation to other information nodes in the hypertext program and to help them locate needed information (Smith and Wilson 1993).

In addition, disorientation causes poor user performance and increased cognitive load, hence reducing the mental resources available for learning (Tripp and Roby 1991). The type and extent of cognitive resources required to read hypertext has been a concern (Wenger and Payne 1994). If mental resources are engaged by navigational tasks and if these same resources are required for learning, user performance will suffer because part of the mental resources were used for navigation tasks. Disorientation is more likely to occur in a hypertext program that has extensive information because users will experience a large number of choices about which links to follow and which to leave alone. The disorientation problem will intensify as databases expand to accommodate increasing amounts of information.

Other researchers (e.g., Halasz 1988; Jonassen 1988; Utting and Yankelovich 1989) have focused on possible increases in the demands placed on memory and the potential for becoming disoriented in the structure of the information, associated with the freedom of navigation that hypertext allows. This freedom may cause a greater potential for users to become lost or disoriented (Conklin 1987).

Foss (1989) remarks that navigation problems occur because of the nature of hypertext -- a hypertext document contains large amounts of information in which the reader may be interested. The first navigation problem Foss (1989) suggests is the problem where users lose track of their search for needed information, and the problem becomes worse when interesting information detracts from the main task. The second navigation problem Foss (1989) suggests is the "art museum" phenomenon where unfamiliarity with the subject matter or interference caused by viewing a large number of items makes it difficult for users to form a coherent understanding of what has been viewed. These two problems would hinder users from locating information they need.

In summary, when searching information in a hypertext environment, users encounter the navigation problem as a result of a program containing large amounts of information connected via links. The consequences of disorientation are that users waste mental resources on unnecessary navigation tasks and fail to find information they need.

Previous Attempts to Solve Disorientation Problem

To alleviate the problem of disorientation, technical communicators have suggested limiting the number of links because extensive linking may not be desirable (Glushko 1989). They should establish an exploration space that contains no irrelevancies (Grice et al. 1991). They may designate search links so that users cannot access material irrelevant to a path. However, if a technical communicator limits the number of links or the amount of information in a hypertext program, the presented information, particularly in a large database, will be author-oriented rather than reader-oriented because the author, not the user, determines what information is relevant to the search.

Another way to improve user performance is to give users a graphical representation of the structure of the hypertext program (Gaines and Shaw 1995). A graphical representation of the structure of the information, or graphical browser, may alleviate user disorientation. Graphical browsers can provide readers with some form of overview of the contents and structure of the material (Smith and Wilson 1993).

Utting and Yankelovick (1989) describe a hypertext program that uses a global map and a local map to alleviate the disorientation problem. Users of the program can display these maps by using appropriate buttons on the screen when they want to find where they are in relation to other nodes in the program. The global map portrays every document in the entire hypertext program and the links between them, as shown in Figure 2.

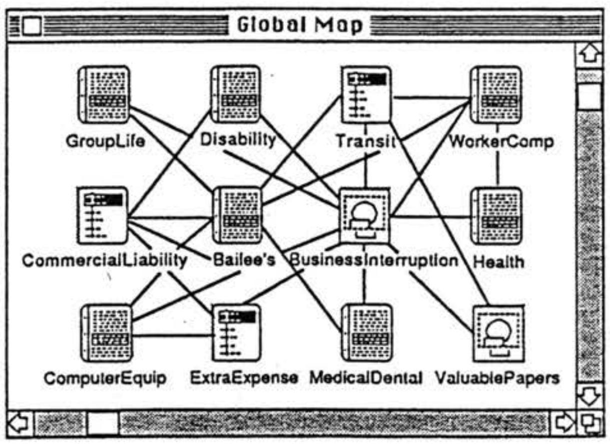
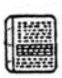


Figure 2. Global map (Source: Utting K., and N. Yankelovich. 1989. Context and orientation in hypermedia networks. ACM Transactions on Information Systems 7 (1): 63).

Figure 2 shows a global map for an entire hypertext program. (Utting and Yankelovick (1989) did not explain why they used three types of icons, i.e.,  , , and , to represent the documents.) The global map shows the links between documents and the possible links users may go from one document to another.

The local map shows a particular "focus" document the user specifies, and the document to which it was linked, as shown in Figure 3.

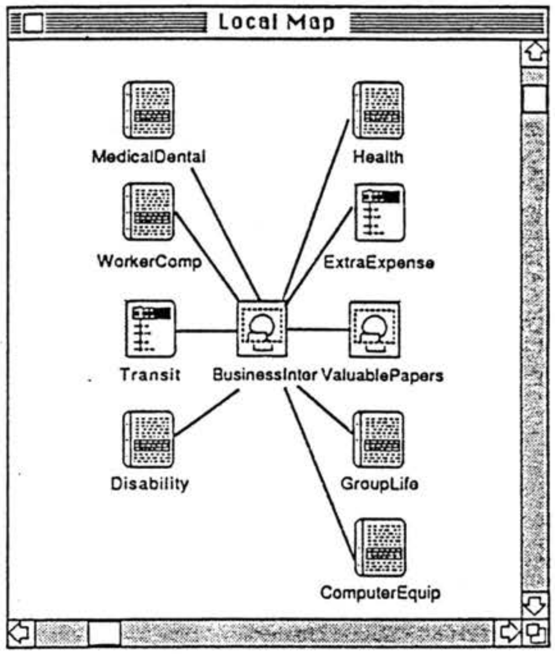


Figure 3. Local map (Source: Utting K., and N. Yankelovich. 1989. Context and orientation in hypermedia networks. ACM Transactions on Information Systems 7 (1): 63).

In Figure 3, the focus document is the one labeled "BusinessInter[ruption]" in the middle of the picture. The map also shows the documents that link to the focus document. The major function of a local map is to show the position of the current document in relation to other documents in the hypertext program.

Utting and Yankelovich (1989) remark that a global map is effective for a small hypertext program, but for a program containing a large number of documents, it is not effective because such a map will become too large and too cluttered to be useful for users to find information. A local map is more useful than a global map because it shows only the documents that link to the focus document. Showing only part of the links, instead of all the links, will not clutter the screen.

While no empirical evidence on the effectiveness of a program using global and local maps is available, Wenger and Payne (1994) conducted an empirical study to examine the effect of a graphical browser on comprehension and retention of hypertext. A graphical browser represents the structure of the hypertext program. The representation indicated all the available nodes (screens of information) in the program, as shown in Figure 4 below.

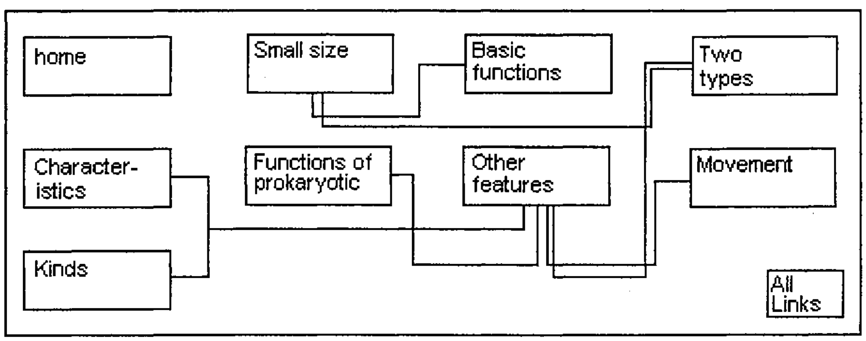


Figure 4. Graphical browser showing the available nodes in a hypertext program (Source: Wenger, M. J., and D. G. Payne. 1994. Effects of a graphical browser on readers' efficiency in reading hypertext. Technical Communication 41(2): 229)

Figure 4 shows the browser representation of the hypertext program in Wenger and Payne's study. The node labeled "Small size" was the node from which the user activated, or displayed, the browser. A user could display all the links to a node by placing the mouse cursor on the node and pressing the right mouse button. As shown in Figure 4, the user places the mouse cursor on the node "Other features" and presses the right mouse button to display all the nodes connected to it.

In Wenger and Payne's study, the experimental group read a hypertext program that had a graphical browser, as shown in Figure 4. The subjects in the group could display the graphical browser by choosing the button on each of the nodes. The control group read the same hypertext program, but the program did not have the graphical browser. The results show that the graphical browser had no effect on recalling text structure. However, the researchers did find that the browser increased the amount of text users read and reduced the number of nodes users repeated during reading.

The graphical browser Wenger and Payne (1994) used was similar to the one Utting and Yankelovich (1989) suggested. Wenger and Payne's browser could display all links in the hypertext program, performing the function of a global map. Also, their browser could display all documents that link to a "focus" document, performing the function of a local map. The focus document is the document from which the user activates the browser. Because Wenger and Payne's hypertext program contains only 9 nodes, the browser was effective to show the structure of the hypertext program. The value of Wenger and Payne's experiment is that they provided empirical evidence of the effect of graphical browsers on users' efficiency in reading hypertext.

Wenger and Payne's browser could represent all the links in the program without cluttering the screen because the program contained only seven nodes. However, most graphical browsers suffer from the problem of screen space limitations (Smith and Wilson 1993). In large hypertext systems, users can view only a small area at any one time. Although users can scroll and resize a window (i.e., a portion of the computer screen that displays information), they find it difficult to use and interpret the information presented on the screen as the number of nodes and connections increases (Foss 1989).

In addition to using graphical browsers, other researchers (Rizk et al. 1990; McKnight et al. 1991) suggest using metaphor as a method to help users learn a computer program. For example, a widely used metaphor is the desktop metaphor. With this metaphor, a computer program uses small graphics, or icons, to represent its functions (I will give details about this metaphor in the following section). However, no research on using icons as a navigation in hypertext programs is available. My research primarily examines using visual metaphors as a navigation aid in hypertext programs. The following sections discuss metaphors and their uses in computer user-interface design.

Using Metaphors in Computer Interface Design

In *Poetics*, Aristotle remarks: "Metaphor consists in giving the thing a name that belongs to something else." He also adds that "To employ metaphors effectively it is necessary to have an eye for resemblances." A metaphor is "a device for seeing something in terms of something else. . . . It brings out the thisness of a that or the thatness of a this" (Burke 1945: 127). These notions of a metaphor reflect a view of the nature of the metaphor, i.e., a metaphor is a comparison. A metaphor "identifies one object with another and ascribes to the first object one or more of the qualities of the second" (Holman 1986). In other words, a metaphor is a comparison in which one term is assumed to bear a partial resemblance to something else.

To identify the components of a metaphor, Richards (1936) introduces two technical terms: "tenor" for the subject to which the metaphoric word is applied and "vehicle" for the metaphoric word itself. He uses "tenor" to refer to "the original idea," "what is really being said or thought of," "the underlying idea," or "the principal subject." He uses "vehicle" to refer to "the borrowed one," "what it is compared to," "what imagined nature," and "what it resembles." In short, the tenor is "the underlying idea or principle subject which the vehicle or figure means" (97). Richards also uses the word "ground" to refer to the relationship, or the similar features that the tenor and the vehicle share. The ground of a metaphor consists of common characteristics shared by tenor and vehicle (Ortony 1979). Once readers have detected the ground of the intended analogy, they can retrace the author's path and search the original literal meaning (Black 1962). For example, "Her words are gospel." In Richards' parlance, "her words" is the tenor, and "gospel" is the vehicle. "Gospel" modified "her words," and the ground of the metaphor means the similarity that what she says ("her words") is as authoritative as the Bible ("gospel"). Richards' idea of tenor and vehicle allows us to distinguish between the two major components in a metaphor.

I. A. Richards' notion of "tenor" and "vehicle" is also relevant to analyzing an icon. For example, a technical communicator uses a picture of a folder to represent a "place" to store documents. The icon itself is the tenor, and the idea it represents is the vehicle. In this case, the metaphor does not state the vehicle explicitly. Users of the folder icon will have to interpret it based on their associations of the icon. The users may use the "ground" of the metaphor to examine if they interpret the icon correctly because, as mentioned in the previous paragraph, the "ground" of a metaphor refers to the relationship, or the similar features that the tenor and the vehicle share.

An additional factor in interpreting metaphor is the context in which it occurs (Langer 1957). The context tells readers to interpret the expression metaphorically. Langer (1957) gives an example to explain her point. One might say of a fire: "It flares up." The expression clearly indicates the action of a fire. However, one would not interpret the expression literally as a reference to a physical flame if someone says: "The king's anger flares up." She adds that if a metaphor is used very often, people will accept its metaphorical context as though it had a literal meaning. For example, "the brook runs swiftly," in which the word "runs" does not imply any movement of the legs.

A metaphor is not only a figure of speech used to bring to light shared qualities or resemblances between subjects, but also an organizing principle for understanding a concept. Lakoff and Johnson (1980: 1) argue that "our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature. . . The way we think, what we experience, and what we do every day is very much a matter of metaphor." People tend to try to learn about new concepts by making use of their prior learning. They generally think of new concepts in terms of old concepts. Because metaphors use prior knowledge, they are a vital part of human cognition. Novel concepts are understood through comparisons to experiences. For example, people may have difficulty understanding how the central processing unit (CPU) works in a computer. A metaphor to indicate the function of a CPU is "the CPU of a computer is the brain of the computer." Because most people understand the basic functions of the brain, the human-brain model is an effective metaphor to understand the functions of the CPU. Once they associate the functions of the human brain with that of the CPU, they begin to understand how the CPU works, although they are aware that the CPU is not exactly the same as the human brain.

Studies have shown that metaphors can play a major role in learning new material (Vosniadou et al. 1988; Evans 1988; Hayes et al. 1982). For example, Hayes et al. (1982) examined if metaphors could help American students learn about a new sport. The experimental group read a passage about cricket, a game less familiar to the group. The passage about cricket used metaphors from the game of baseball to present cricket. The control group read the passage about cricket but the passage did not contain baseball metaphors. The results showed that the experimental group recalled more about the cricket passage than the control group.

In another experiment, Evans (1988) conducted experiments to determine if metaphors helped university students learn statistical concepts. In the experimental group, the researcher taught the subjects material that used metaphors to explain statistical concepts. The metaphors used in the experimental group were analogies or examples from domains other than statistics. The topic of the lecture was to apply statistical methods to make business decisions. In the control group, the researcher taught the subjects the same material but used examples of scientific methods applied to business. The results showed that students taught with metaphors learned better how to apply statistics to make decisions. In the same study, Evans also conducted an experiment to test whether metaphors improved the inferences students made in answering questions based on the information presented in the lectures. The results showed that students taught with metaphors could apply the concepts taught in the lecture more effectively to make appropriate inferences than students taught without metaphors.

The empirical studies described in the above paragraph concern using metaphors to help people learn new concepts. Technical communicators also use metaphor to help novice users comprehend a computer system or application (Rizk et al. 1990; McKnight et al 1991). They use metaphor to suggest a comparison of a new computer environment to an environment with which users are already familiar. The reasoning behind using metaphor is that it enables users to apply the knowledge they have acquired into the new knowledge they are acquiring. For a metaphor to be effective, the old knowledge must provide a reasonable match to the new knowledge. Because people use metaphors to learn about computing systems, technical communicators should anticipate and support likely metaphorical constructions to promote the ease of learning the system (Carroll and Thomas 1982).

Implementing metaphors in computer applications is pervasive and growing in interface design. Table 1 shows computer programs that use metaphors to help users how to learn the programs.

Table 1. Metaphors used in interface design (adapted from Carroll et al, 1988)

Application area	Systems	Metaphor	Use knowledge of
Word and text processing	WordStar, Display	Typewriting	Typewriting, typing paper, keyboard
Advanced document composition (formatting languages, desktop publishing, composite editors, structured editors)	Interleaf, PageMaker	Document	types of graphical text objects and their attributes
database management	dBase III	Table of data	matrix-structured data: rows and columns
Spreadsheets	Lotus 1-2-3	Ledger sheet	matrix-structured numerical data

As shown in the above table, what metaphor to use depends on the nature of the application. For example, a database application, e.g., dBase III, uses the table metaphor so that users can create databases by using tables. Because most users have knowledge of using tables to organize data, the table metaphor helps them learn how to use the application.

A widely-used metaphor in a computer environment is the desktop metaphor, in which small pictures, or icons, represent various functions of a program or operating system. Table 2 below shows some of the icons used in the Windows™ 3.11 operating system to represent different utilities.

Table 2. Icons in the Windows™ operating system

Icon	Program	Function	Use knowledge of
	NotePad	make short notes or documents	a note pad to jot notes
	Printer selection utility	select a printer	a printer
	Calculator	perform simple calculations	operations of a calculator

The icons in Table 2 represent items on an office desk. These icons are metaphors because users may have different interpretations. For example, the designer of the notepad icon uses this icon to represent a computer program that allows users to write short notes and documents. If users are new to the Windows™ 3.11 operating system, they may interpret it as a note to using the operating system because they may have seen it used as an icon to draw their attention to a note in a user manual. Therefore, an icon is likely to have more than one interpretation. Shirk and Smith (1994) point out the metaphorical nature of icons:

> Icons are characterized by their smallness and pragmatic-functional representational qualities. They always stand for something else, and, in this sense, if designed correctly, they are always inherently metaphorical. (682)

According to Shirk and Smith (1994), icons are metaphors in nature because they always represent something else. For example, the folder icon on the computer screen represents a sector in the hard disk or floppy disk in which users can store information. The folder icon is not a physical folder a person uses to file documents in the office. Because icons are metaphors presented in graphical format, I consider icons to be visual metaphors.

In computer programs, not only pictures, but also words have come to be called "icons" (Familant and Detweiler 1993; Guastello et al. 1989). For example, I find that the Netscape™ web browser uses the following icon (a web browser is a program that allows users to view information on a World Wide Web site):

The word "Home" allows users to return to the first page of the Netscape web site. However, Li (1993) disagrees that such words are icons, arguing that not any textual element surrounded by a box on the computer screen is an icon; an icon has to have visual components that are recognizably and functionally related to the object or action that it represents. However, technical communicators can place text in a small box and call it an icon. For the sake of convenience, I call this type of icon "text icon." A text icon may be a metaphor but is not a visual metaphor because text icon lacks the visual component. It is a metaphor because users may interpret the text icon differently. For example, the HOME text icon may mean to return to the beginning of a document, instead of the first page of the Netscape™ web site. Because a text icon is a metaphor, one may use Richards' notion of "tenor" and "vehicle" to analyze it. For example, the text icon "Home" is the tenor, and the meaning users identify is the vehicle.

Many programs use a combination of picture and word in the icons. If an icon is not obvious to users, the icon author should label it (Horton 1994). However, after users are familiar with an icon, they may not need the text accompanying it. I notice the Netscape™ web browser allows users to display icons on the menu bar in picture, text, or both, as shown in Figure 5.

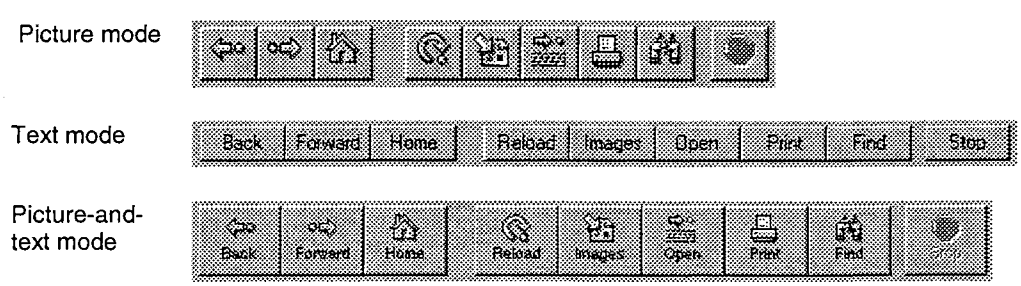


Figure 5. Icons on the Netscape Browser displayed in icons, text, or both.

Allowing users to have a different display mode indicates that users may want icons displayed only in picture format after being familiar with meaning of the icons.

In this dissertation, the icons I used consisted of graphics instead of words because my experimental design was to examine the effectiveness of using visual metaphors and word labels. The metaphors were composed of small pictures, and the labels were composed of words.

Theoretical Basis for Using Icons

As mentioned in the previous section, icons are metaphors presented in graphical format. Researchers can apply theories of graphics to examine the effectiveness of icons. When studying the effectiveness of icons, many researchers (e.g., Muter and Mayson 1986; MacGregor 1992) compare the effectiveness of icons with words. In this section, I will discuss the theoretical basis for using graphics to help users perform a task in the computing environment.

In general, researchers believe that graphics help users memorize information and therefore help them learn information, although memory and learning are two different cognitive activities. Strong support for asserting that graphics help memory and learning comes from Paivio's dual coding theory (Paivio 1971; Paivio

1973; Paivio 1990). He suggests that human beings have two independent encoding mechanisms: one visual and the other verbal. The visual system is specialized for the representation and processing of information concerning nonverbal objects and events, and the verbal system is specialized for dealing with language. The mode of stimulus presentation determines which system will become active. Pictures are predominantly encoded nonverbally, or as pictures, whereas words are encoded verbally, or as words (Paivio 1971; Paivio 1973; Paivio 1990).

Dual coding is more likely to occur when the content indicates concrete concepts, such as "tree" and "chair" (Paivio et al. 1973). These concepts readily produce internal images in most people. Also, research shows that words, sentences, and paragraphs that are highly imageable are recalled better than those that are not (Paivio 1986). The visual and verbal systems are independent: either system can become active without the other, or both systems can be active simultaneously (Paivio 1990).

Paivio also contends that it is easier to retrieve an item from memory storage if it is represented in two ways than if it is represented in one way. To relate dual coding theory to memory, Paivio (1971) argues that words with high-imagery scores should be easier to remember than words with low-imagery scores. A word with a high-imagery score is one that a person can readily encode into a picture, e.g., a chair. A word with a low-imagery score is one that a person cannot readily encode into a picture, e.g., courage. A person can form an image from a word with higher imagery score faster than a word with low-imagery score. To examine his hypothesis, he gave subjects a series of words and asked them to form a visual image of each. Then he used the recorded times and calculated an imagery score for each word. He found that the subjects remembered more words with higher-imagery scores than words with lower imagery scores.

A recent study on examining how well subjects remembered pictures and words (Dewhurst et al. 1994) also supports Paivio's results that high-imagery words are more likely to be remembered than low-imagery words. Highly imageable words produce rich, distinctive memory traces that are more likely to be recognized than words that are low in imageability.

In addition to asserting that people can encode words and pictures in dual representations, Paivio (1971, 1991) has found that pictures are superior to words in promoting information retrieval. He explains that pictures are likely to be spontaneously named, which results in two memory traces instead of only one, with a consequent increased probability of retrieval. Words may be similarly dually encoded if accompanied by visual imagery, but this is less likely to occur spontaneously. Retrieval rates are higher for pictures than for concrete words, and higher for concrete words than for abstract words.

Hodes (1992) compared the effect of imagery instructions and visual illustrations. Imagery instructions are text that instructs subjects to form mental images, whereas visual illustrations are visuals in a text passage. The test materials included a text-plus-imagery instructions passage and a text-plus-illustrations passage. The researcher had the subjects read one of the versions and then had them take a recognition and recall test. Hodes found that subjects in the text-plus-visual-illustrations group used imagery more effectively than subjects in the text-plus-imagery-instructions group. The research results supported Paivio's theory that visual illustrations evoke both non-verbal and verbal encoding of information. Familiar and unambiguous illustrations enhance the availability of both verbal and non-verbal process. Visual illustrations are image evoking and promote dual coding.

Other empirical studies also suggest the superiority of pictures over words. Shepard (1967) and Nickerson (1965) conducted experiments in which they showed the subjects a large number of pictures and subsequently gave them a recognition test. The results showed that the subjects identified the pictures with high levels of accuracy, even with long intervals between presentation and testing. Subjects could recall more objects presented as pictures than presented as words (Gribbons 1991).

Paivio's dual coding theory and other studies on the superiority of pictures over words will help me interpret the results of my research, particularly the performance of the subjects who repeated the tasks.

Research on Icons

In the remainder of this section, I will discuss the empirical studies on the effectiveness of icons and text in different computer settings, such as menu-driven and task-oriented environments. Most importantly, I will point out that we do not have empirical evidence that using icons can help users navigate in the hypertext environment, although researchers, which I will mention in this section, have conducted studies in other environments.

Researchers have examined whether using icons in human-computer interaction enhanced user performance, and their results vary. Muter and Mayson (1986) compared menu selection for a text-only menu to a text-plus-graphics menu. The text-plus-graphics menu shows the text supplemented by simple graphics. The researchers gave subjects search questions, such as "Where can you find a food processor?" and the subjects had to select the appropriate menu item. The researchers found that adding icons to textual menu pages reduced user errors by 40 percent, but had no reliable effect on response times, although the mean response time in the graphic condition was slightly lower than in the textual condition. Muter and Mayson (1986) explained why adding icons may improve accuracy. First, icons may give additional information to the menu items. Second, the subjects may extract semantic meaning more effectively from graphics than from words.

Although Muter and Mayson found that icons may have a positive effect on menu selection, their research gives no evidence as to whether the positive effect was attributed to the combination of text and graphics or to the visual characteristics of the simple illustrations used in the study. Also, Muter and Mayson did not conduct the experiment in the hypertext environment. Their test environment did not involve any hypertext links. They photographed the computer screens and turned the pictures into slides. The subjects in the study viewed the objects on slides instead of on a computer screen. Searching information on slides differs from searching information in a hypertext program because one does not need to navigate from screen to screen to look for information on a slide. The study of Muter and Mayson (1986) did not require subjects to navigate, the results would explain only the subjects' response times to the icons, but not the effect of the icons on navigation.

Expanding Muter and Mayson study, MacGregor (1992) used three different versions of menu pages adapted from a national videotex system, which is a large database of general and consumer information. In one version, the menus consist of labels only, in the second, of the labels plus text descriptors, and in the third, of the labels plus icons.

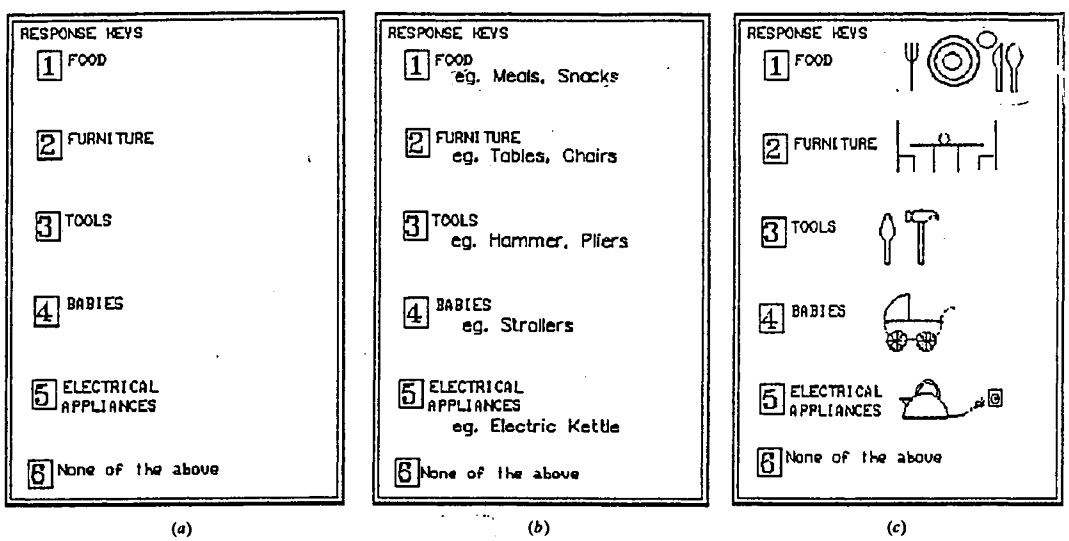


Figure 6. Label (a), Descriptor (b) and Icon (c) versions of the menu page (Source: MacGregor, J. N. 1992. A comparison of the effects of icons and descriptors in videotex menu retrieval. International Journal of Man-Machine Studies. 37: 770)

A text descriptor, as well as an icon, gave examples to its label. For example, one label used the word "food."

Its text descriptor was "meals/snacks," and the icon was a drawing of silverware. The results indicated that adding icons to videotex menus had the same effect as adding equivalent textual descriptors. Neither reduced response times, while both reduced errors by the same amount (40 percent). Furthermore, the effect of both icons and descriptors was entirely attributable to a reduction in a specific type of error. In the absence of either icons or descriptors, subjects frequently failed to recognize any of the menu options as relevant, including the correct one, and wrongly selected the "none of the above" option. Adding descriptors and icons appeared to specify the contents of categories sufficiently to reduce this type of error.

In another experiment, Wandmacher and Muller (reported in Arend et al. 1987) studied the effect of two presentation modes for selecting menu items: word commands versus icons on menu selection. In this study, the researchers gave each subject a task description and then either a menu of word commands, such as "Delete," "Display," and "Edit," or menu of icons. Subjects performed a task, for example, "You want to delete a document" with menus showing either the word commands or the icons. Contrary to the Muter and Mayson's research results, Wandmacher and Muller found that neither the word version nor the icon version had an effect on error rates. However, they found that the subjects in the icon version completed the assigned tasks faster than those in the word version.

Switching from a menu item selection environment to a task-oriented environment, Lansdale et al. (1990) examined using words and icons in an information-retrieval task. Specifically, the researchers investigated whether pictorial attributes, such as color, location, and shape, were more effective than their verbal counterparts in helping subjects retrieve documents annotated with icons. The researchers found that whether enriching attributes are verbal or pictorial was not likely to affect the subjects' ability to retrieve needed information.

Using an electronic mail environment, Benbasat and Todd (1993) investigated the effects of iconic and textual interfaces on the performance of casual users using electronic mail. One version of the electronic mail program used an iconic menu and buttons, and the other version used text-based menu and buttons. Results indicate that no advantages were associated with iconic representations compared to text-based representations of actions and objects. The subjects primarily used one screen to complete their tasks and did not need to navigate in the program. Rogers (1989) conducted a study comparing command names and various kinds of icons for use on menus as part of a word-processing task. He found that icons had no particular advantage over words, but the long-term memory of how to perform a task was better with icons. Other researchers (Shepard 1967; Standing et al. 1970; Banks and Flora 1977) have also found that pictures aided memory.

The above studies all indicate that using icons is as effective as using text in the menu-selection environment. However, the researchers conducted these studies in a menu-selection environment, not in a hypertext environment. Selecting an option on a menu does not involve navigating through nodes of information. This type of navigation is the primary characteristic of hypertext. Because the researchers conducted their studies in a menu-selection environment, their results may not directly applicable to a hypertext environment. However, they may serve as a reference for me to examine whether the results will hold true when a computer program requires subjects to navigate through links of information.

In addition to conducting their studies in a menu-selection environment, the researchers did not discuss the effectiveness of the icons they used in their studies. Researchers need to make sure that the icons they use in their studies are effective. Poor icons will cause low user performance because users will have problems understanding their meanings and hence using them to search for needed information. In my research, I conducted an icon-recognition test to examine the effectiveness of a set of icons and selected those that were effective to represent their intended meanings.

The notion of "articulatory distance" can determine the effectiveness of an icon. According to Blankenberger and Kahn (1991), "articulatory distance" means the "distance" between the icon interpreter's meaning of the icon and the icon author's meaning of the icon. The interpreter is a person who decodes the meaning of an icon. One may quantify the articulatory distance of an icon in terms of the percentage of interpreters who correctly identify the icon's meaning the icon author intends. For example, if 60 out of 100 interpreters identify correctly the meaning of an icon, the articulatory distance is 60 percent. The higher the percentage of the articulatory distance, the more effective the icon is. In other words, the percentage of the articulatory distance of an icon is an index of the effectiveness of the icon. Figure 7 illustrates the concept of the percentage of the articulatory distance of an icon.

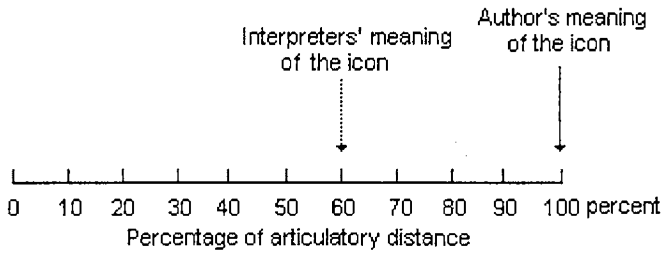


Figure 7. Articulatory distance of an icon expressed in terms of percentage of interpreters who correctly identify the icon.

As shown in Figure 7, the dotted arrow indicates that the articulatory distance of the icon is 60 percent. The percentage means that 60 percent of the interpreters identify the author's meaning of the icon correctly.

The percentage of an icon's articulatory distance varies according to the attributes of the icon. If an icon has attributes of effective icons, a high percentage of interpreters can identify its intended meaning. The following section points out attributes of effective icons.

Attributes of Effective Icons

Horton (1994) provides technical communicators with a list of attributes of effective icons. Effective icons are unambiguous, familiar, and legible. These attributes directly influence how the interpreter decodes an icon, or what the articulatory distance of an icon is. For example, if an icon is ambiguous, the articulatory distance will increase, the percentage of interpreter identifying it correctly will decrease, and therefore the effectiveness of the icon will decrease. In my research, I conducted an icon-recognition test to examine the effectiveness of a set of icons and selected those that were effective to represent their intended meanings. Following are the attributes I used to analyze the results of the icon-recognition test.

- Unambiguous

  An unambiguous icon causes viewers to associate it with only one concept. A technical communicator should use additional clues available to resolve any ambiguity. For instance, in the Microsoft™ Word™ program, the icon for the spell checker is a check mark with the letters "A," "B," and "C." If the technical communicator only used a check mark, the icon would mean, for example, placing a check mark at the beginning of a line, as a bullet would do. However, the letters, along with a check mark, give users additional clues that they can use the icon to check letters or spellings.

  The notion of articulatory distance is applicable to explain the relationship of an icon's ambiguity and percentage of articulatory distance, an unambiguous icon increases the percentage of the articulatory distance and therefore enhances the effectiveness of the icon.

- Familiar

  A familiar icon is one that users have already learned its meaning from other sources. For example, many graphics programs use the magnifying glass metaphor to represent a function to enlarge a picture. Graphics artists do use a magnifying glass to examine small pictures, so this tool is an item whose functions graphics artists are familiar with.

The notion of articulatory distance is applicable to explain the relationship of an icon's familiarity and percentage of articulatory distance, a familiar icon increases the percentage of the articulatory distance and therefore enhances the effectiveness of the icon.

- Legible

  Icon legibility means users' ability to recognize clearly the object depicted in the icon. A legible icon allows viewers to recognize its components, such as points, lines, and shapes. If viewers cannot recognize these components or misidentify them, they are not likely to guess its intended meaning.

The notion of articulatory distance is applicable to explain the relationship of an icon's legibility and percentage of articulatory distance, a legible icon increases the percentage of the articulatory distance and therefore enhances the effectiveness of the icon.

These attributes are useful for technical communicators to evaluate the effectiveness of an icon. I used these attributes to analyze the results of the icon-recognition test. Also, if my study found that icons were more effective than words in helping users navigate in hypertext programs, technical communicators would need to use these attributes to design effective icons.

Summary

This chapter examines the literature on the disorientation problem in hypertext and possible solutions to the problem. Hypertext researchers point out that disorientation causes users to waste mental resources on unnecessary navigation tasks and therefore causes them difficulty locating needed information. Possible solutions include using global and local maps and limiting the amount of information in hypertext programs. However, these solutions have drawbacks. For instance, a global map may not be effective or possible to present the structure of a large hypertext program that consists of hundreds of links.

Researchers have suggested using metaphor and visual metaphor (or icons) to help users learn how to use a computer system, but they do not place emphasis on solving the navigation problem in hypertext. Research on using icons and words in computer programs indicates that icons were not more effective than words in helping users search for information. One reason may be that the icons were not well designed, consequently causing the subjects difficulty interpreting the icons. Using effective icons is important because all studies use response times and accuracy as dependent variables to measure whether icons are more effective than words. Poor icons would naturally lead to low accuracy and long response times.

In addition to the uncertainty of the quality of the icons used in their studies, previous researchers conducted their experiments in the menu-selection environment, not in the hypertext environment. In other words, the computer programs used in the studies did not consist of hypertext links. Linking information nodes is the major characteristics of the hypertext environment. The research results may have been different if they had conducted them in the hypertext environment. Locating information on a series of menus in a hypertext program is different from on a single screen because in a hypertext program users may encounter navigation problems that affect user performance. However, navigation problems would not occur when users try to find information on a single screen. My research used a hypertext program, and the subjects searched for information in a hypertext environment instead of a menu-selection environment. In this way, I could adequately apply my results to solving navigation problems in hypertext programs.

In addition to conducting the studies in a menu-selection environment, the researchers did not account for the subjects' experience with using icons. I believe that someone having more experience with computer icons tends to interpret icons more readily than someone having less or without experience with icons. In my research, I gathered information about the subjects' computer experience with the iconic user interface and examined if the experimental group and the control group had similar computer experience.

To summarize the differences between previous studies and my research on hypertext navigation, my research is unique in the following ways:

- The effectiveness of the icons used in the research were tested to make sure that they were effective.
- The research was conducted in the hypertext environment, not in the menu-selection environment.

* The subjects' experience with computers was taken into consideration to make sure the control group and the experiment group had similar computer experience.

Conducting my research in these ways allowed me to examine my research question adequately, particularly the computing environment I used was hypertext. The major objective of my dissertation was to answer the question of whether using icons is effective in helping users navigate in hypertext. Also, based on the results, I can give technical communicators suggestions for alleviating navigation problems in hypertext.

CHAPTER 3: METHODOLOGY

The methodology section describes the experimental design, procedures, materials, subjects, and analytical methods I used for the empirical study. The Institutional Review Board of Oklahoma State University approved using human subjects for this study (see Appendix ? for the approval form).

Design of Experiment

As mentioned in Chapter 1: Introduction, to answer the research question whether using icons is an effective navigation aid in hypertext, I intended to conduct an experiment to examine whether a hypertext program using icons can help users navigate more effectively than a hypertext program using words. The purpose of using the experimental method is to account for the influence of a factor or factors in a research situation (Leedy 1989). In its simplest form, this method introduces a factor, or variable, in a research situation and examines any changes as a result of introducing the variable. This approach is appropriate because my research objective was to examine the effect of icons as a navigation aid in a hypertext program.

To examine my research question whether a program using icons was more effective than a program using words in helping users navigate in hypertext, I intended to measure and compare the times the icon group and the word group used to complete the tasks under three conditions, as mentioned in Chapter 1: Introduction. Because the completion times were the variable I wanted to measure, the dependent variable was the times it took the two groups to complete the tasks. After measuring the times, I conducted a t-test to examine whether the completion time of the icon group was significantly faster than that of the word group. The two independent variables I used in the study were the familiarity with the icons used in the hypertext program I designed and the familiarity with using the hypertext program to find information. I will discuss how I used these variables in the "Designing Navigation Test Questions" section on page 63.

Subjects used this program in the Macintosh™ operating system. Selecting to run this program in the Macintosh™ operating system or the Windows™ operating would not influence subjects' performance because I could design this program in the Windows™ or Macintosh™ environment and the resulting program would have the same features in either environment. The subjects used the program, not the operating system. In other words, the operating system was transparent to them.

In my research, I designed two versions of a hypertext program that represented an electronic shopping mall. Figure 8 shows a three-dimensional sketch of the shopping mall.

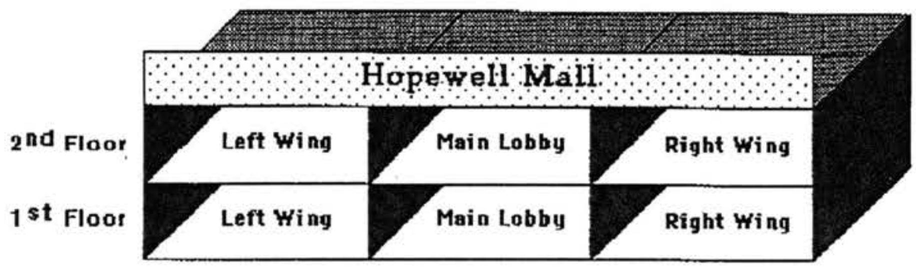


Figure 8. Setting of the electronic shopping mall.

As shown in Figure 8, this mall consisted of two floors. Each floor had three sections: the main lobby, the right wing, and the left wing, and each section consisted of six stores. Each time, the screen displayed only one section of a floor. Figure 9 below is a sample screen of the main lobby of the first floor for the icon version.

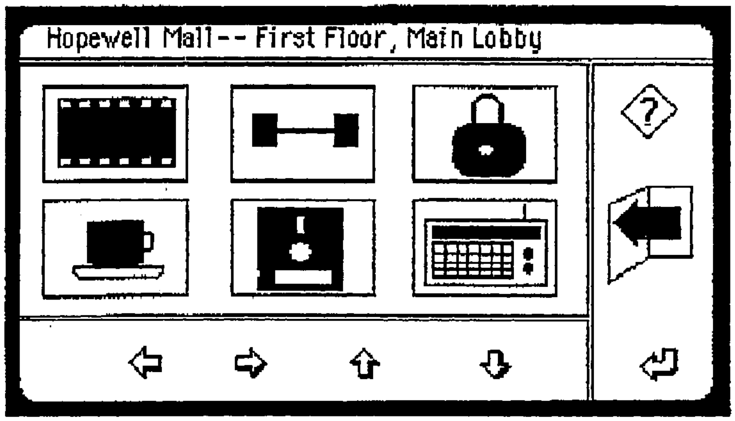


Figure 9. Sample screen of the main lobby of the first floor (icon version).

The icons came from a Macintosh™ clip art package and my own creation. In the text version, I replaced all the icons with text, as shown in Figure 10.

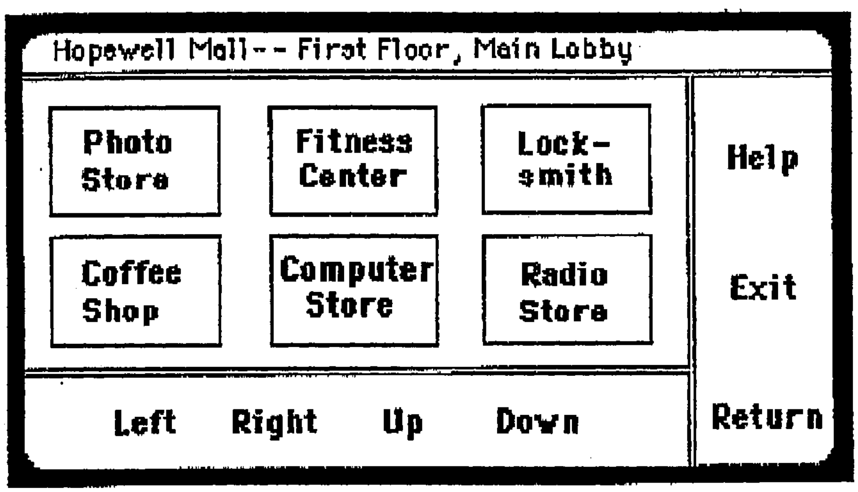


Figure 10. Sample screen of the main lobby of the first floor (text version).

Subjects could go from one screen to another by placing the mouse pointer on one of the navigation buttons and pressing the mouse button. I used arrows to depict these buttons, as shown in Figure 9. For instance, the "up" arrow means going up one floor, and the "down" arrow means going down one floor. Both versions are alike except that one used icons and the other used words.

I chose to use the shopping mall setting for the hypertext program because this setting allowed me to implement icons and test their effectiveness. Also, in a shopping mall environment, subjects needed to "travel" (i.e., go from one screen to another) in order to reach the stores they wanted. The process of going from one screen to another to look for needed information is similar to the process of traveling in hypertext. Also, a large number of World Wide Web sites use the shopping-mall format. A key word search of "shopping mall" via the search engine on the Webcrawler web site yields more than 53,000 entries (Webcrawler is a web site that allows users to search for information on the Internet). Although these entries may present information in different formats, many of the entries I have visited use the shopping mall format I chose to design my hypertext program. The results of my research would benefit technical communicators who design these sites to help users navigate more efficiently. Most importantly, the shopping mall environment allowed me to implement links so as to create a hypertext setting. As mentioned in Chapter 2: Literature Review, previous research on icons did not use hypertext programs; therefore, the results could not apply to hypertext programs. In my research, I used a hypertext program to conduct my experiment so that I could apply my results to hypertext programs.

Procedures

The empirical study consisted of two major procedures. Procedure 1 was an icon-recognition test, and procedure 2 was a navigation test. Thirty-four subjects participated in procedure 1, and fifty-six subjects in procedure 2. A subject could only participate in one procedure. In other words, no subjects participated in both procedures. I will give more details about the subjects in the Subjects section. The following paragraphs explain the purposes of these two procedures and the steps for performing the procedures.

Procedure 1: Icon-recognition Test

The icon-recognition test investigated the effectiveness of the icons I would use to design a hypertext program using visual metaphors. I distributed this test in two Intermediate Technical Writing classes at Oklahoma State University (I will discuss the characteristics of the subjects in the Subjects section on page 68). I chose these two classes for my own convenience because I knew the instructors well. The subjects did not receive any reward for completing the test because it was a 10-minute in-class exercise. I gave a questionnaire that had 54 icons to 34 subjects. Appendix D includes the questionnaire. The first page of the questionnaire indicated that I would use these icons to represent stores in a shopping mall. I had them guess what stores that the pictures in the test would best represent and had them write down their guesses next to the pictures. The subjects did not have a time limit to complete the test, but I told them that they should finish it in about 10 minutes.

I informed the subjects that I would use these icons in a shopping mall environment because the context contributes to the meaning of an icon (Horton 1994). If I had not given them the context, they might have interpreted a certain icon in more than one way. For instance, in the shopping mall environment the baby bottle icon may mean a baby supply store, while in the hospital environment it may mean a maternity ward.

I also informed the subjects that their guesses had to be spontaneous. If they had difficulty figuring out the meaning of a particular icon, they should move on to the next one. Making sure that I use an effective icon is important because a poor icon will hinder navigation in a hypertext program. From the results of this icon-recognition, I chose to use those icons that more than eighty percent of the subjects guessed correctly.

The icon version of the hypertext program consists of navigation buttons, as shown in Figure 11.

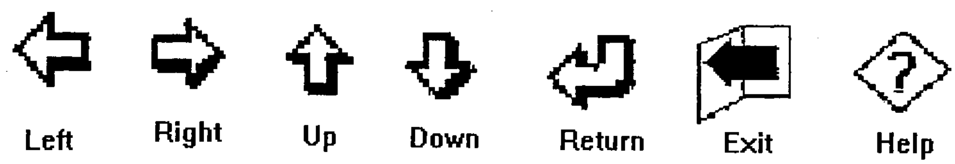


Figure 11. Navigation buttons in the icon version of the hypertext program (the icon version does not have the labels).

The icon version of the hypertext program had only the icons, not the words. I labeled them in Figure 11 only to indicate their meanings I intended. I did not include these icons in the icon-recognition test because the introductory information in the hypertext program I designed for the navigation test informed the subjects in the icon group about the meanings of these icons. They all read the information and therefore were familiar with the icons before starting the navigation test.

Procedure 2: Navigation Test

The navigation test examined whether a hypertext program using icons could help users navigate more effectively than a hypertext program using words, under each of the three conditions. As mentioned previously, I designed two versions of a hypertext program. See Appendix B for the printed copy of the two versions of the program. The first eight pages introduce the shopping mall, and the remaining pages are the screen prints of the shopping mall.

The subjects in the navigation test were all volunteers and were not the same as those who participated in the icon-recognition test. I talked to students in Intermediate Technical Writing classes and asked if they were willing to donate their time to help me with my dissertation research. To encourage them to participate, each volunteer was rewarded with a copy of the technical writing tutorial program I designed for the Technical Writing classes. Twenty-seven subjects participated in the icon version, and twenty-nine subjects participated in the word version. Each subject tried out only one version. I alternately assigned the subjects to either the icon version or the word version.

Each of the subjects performed the navigation test in my presence in an office where the computer equipment, described in the Equipment section, was located. Each time, only one subject conducted the test. I told the subjects about the purpose of the navigation test and the procedure of the test. In addition, both versions of the hypertext program provided them with introductory information about navigating in the electronic shopping. Refer to Appendix B for details on introducing the shopping mall program to the subjects.

After they had read through the introduction section of the hypertext program on the screen, I gave them two test questions to try out. I did not record the times because I intended to give them a chance to become familiar with the setting of the mall and accustomed to using the mouse. See Appendix E for the two test questions.

Designing Navigation Test Questions

As shown in Appendix E, the question paper consists of three exercises. Each of the twenty-seven subjects in the icon group completed all three exercises, using the icon version of the hypertext program I designed. Each of the twenty-nine subjects in the word group completed all three exercises, using the word version. A subject could be only in the icon group or the word group, but not both. I describe each of the exercises below.

Exercise 1

Exercise 1 measured the times subjects in the word group and the icon group needed to travel from one store to another. In this condition (condition 1), the subjects used the icon version of the program, but they did not have any previous familiarity with the icons used in this program. The times would allow me to compare which group completed the exercise faster and hence which version of the hypertext program was more effective. Exercise 1 consisted of six questions, each of which asked subjects to go from one store to another. The times recorded were the times subjects used to locate only one store instead of a cumulative time for visiting all stores so that I could analyze each question individually. As mentioned at the beginning of this chapter, the mall consisted of two floors, each of which had three sections: the main lobby, right wing, and left wing. Each of the six questions required the subjects to click on the mouse button a certain number of times in order to locate a store. For instance, question 1 asked the subjects to go from the optical store on the first floor of the main lobby to the barber shop on the first floor of the right wing. The subjects would need to click the mouse buttons in the following way to complete the task:

1. Click on the optical store on the first floor of the right wing. This mouse click records the starting time. The hypertext program could automatically record the starting time because I incorporated a script to measure the time.

2. Click on the navigation button to go to the second first floor of the right wing. Because the right wing is next to the main lobby, subjects need only make one click to go from the main lobby to the right wing of the same floor.
3. Click on the barber shop. This mouse click allows the hypertext program to calculate the time used to complete steps 1 through 3.

As shown in this example, the first and the last clicks are used for the hypertext program to measure the time to complete the task, and step 2 is used to navigate to the correct section of the floor. In this example, step 2 involves only one click. However, if the distance between the starting store and the target store increases, subjects need to make more clicks. For example, problem 2 in exercise 1 requires subjects to go from the first floor of the right wing to the first floor of the left wing. In this case, subjects need to make two clicks to go from the right wing to the left wing, i.e., one click to go from the left wing to the main lobby and one more click to go from the main lobby to the left wing. I measured only the time to go from the starting store and the target store. I did not measure the time from the starting store to the navigation button because I gave subjects two trial questions to practice and they used the navigation buttons and therefore knew their meanings before starting the actual test.

To allow the subjects to travel in different directions in the hypertext program, I designed the questions in such a way that some questions required them to travel a longer distance than the others. The longer they traveled, the more clicks they needed to make. Question 1 required only one click, questions 2, 3, 4, and 6 required two clicks of the mouse, and question 5 required three clicks of the mouse. Question 6 involved only one click because I wanted the subjects to return to the starting position to be ready for the next exercise. The six questions gave the subjects opportunities to travel different "distances" to locate stores.

During the test, if subjects failed to locate an icon or located an incorrect store, I would tell them what the correct icon was. The time the shopping mall program recorded would still be the time to locate the correct one. The program would record a longer time if subjects located a wrong store because the time kept running until they found the correct store.

Exercise 2

Exercise 2 examined the research question that a hypertext program using icons could help users search for needed information more effectively than a hypertext program using words under the condition that the subjects had become familiar with the icons in the hypertext program and had experience sing the hypertext program. In this exercise, the subjects needed to locate five places consecutively, i.e., the phone booth, bicycle store, golf store, electronic store, and post office. This navigation exercise simulated a situation in which the subjects looked for needed information in a series of steps, while the first exercise measured the times needed to locate only one store.

Because subjects had completed exercise 1, they were familiar with the layout of the hypertext program and the way to use it to find information they needed. Therefore, this exercise compared the completion times between the icon group and the word group under the condition that the subjects knew how to use the program.

Exercise 3

Exercise 3 had subjects repeat exercise 1. I intended to examine the third condition to see how well the word group and the icon group repeat exercise 1 after being familiar with the icons and knowing how to use the hypertext program.

Equipment

The model of the computer the subjects used on the navigation test was a Macintosh™ Classic. The hard drive had 40 megabytes of disk space and 4 megabytes of memory. The monitor was black and white, and was about 7 inches tall and 8 inches wide. The operating system was version 7.0.1. The version of the HyperCard program I used was 2.0. This version provided me with appropriate features, such as creating links, buttons, and graphics, to design the hypertext programs.

Subjects

The two parts of the empirical study used different subjects. This section first explains the possible effects of experience with different operating systems on icon recognition and second describes the subjects in the icon-recognition test and the navigation test.

Experience with Operating Systems

It is important to find out the subjects' experience in using computers in an iconic interface because subjects who are used to icons may be able to locate information in an iconic interface faster than those who are not used to icons. Because familiarity with an iconic interface may affect subjects' performance, I intended to measure subjects' experience with this interface.

The subjects may gain experience with an iconic interface from running a program under a computer operating system that uses graphical elements. An operating system is a computer's controlling or background software (Norton 1990). Many operating systems for the microcomputer are available for computer users, such as DOS (disk operating system), Windows™ 3.x (better known as Windows™), Windows™ 95, Windows™ NT, OS/2, and Macintosh™. Windows™ 3.x has different versions, such as 3.0 and 3.1, but they all share a similar user interface. In this study, I use Windows™ to refer to any version of Windows™ 3.x.

Currently, the most popular operating systems are Windows™, DOS, and Macintosh™. DOS uses a text-oriented command-driven interface, and all the other operating systems mentioned above use a graphical user interface (GUI). A GUI presents information on the screen in which a program is operated by a set of icons, pull-down menus, windows, and dialog boxes (Norton 1990). In the following section, I show the differences among these three major operating systems. Users of an operating system may become accustomed to a particular user interface. For example, users of the Macintosh™ or Windows™ operating system may be more familiar with using icons to search for information than users of the DOS operating system. Therefore, Macintosh™ or Windows™ users may have advantage over DOS users in using the graphical user interface, or DOS users may have advantage using the text-oriented user interface than Macintosh™ or Windows™ users. In my study, I needed to consider the subjects' experience with operating systems when interpreting the results of their performance. Also, future researchers who want to repeat my study may need the following information to understand the characteristics of different operating systems.

DOS Disk operating system (DOS) uses a command-driven user interface. When users want a computer program to perform an action, they have to type a command on the command line and press the Enter key. For example, if users want to use a program, they will need to type a command (e.g., WP) on a command line, and the command will execute the program. In other words, in the DOS environment, users interact with the computer by using words instead of graphics.

Windows™ Unlike DOS's command-oriented environment, the Windows™ environment features a graphical interface. For instance, pictures on the screen represent software applications and system functions. Users interact with the computers by using a pointing device, called a mouse, which controls the movement of a pointer on the screen. Users can activate the functions the icons represent by placing the pointer on the icons and pressing a button on the mouse. For example, if users want to use a program, they will need to place the mouse button on the icon representing the program and press twice the mouse button to open the program.

Macintosh™ Similar to the Windows™ operating system, the Macintosh™ operating system uses a graphical user interface. Although its screen layout differs from that of the Windows™ system, Macintosh™ uses graphical elements such as icons to represent objects on the computer desktop (a screen that displays programs available on the computer). For example, if users want to use a program, they will need to place the mouse button on the icon representing the program and press twice the mouse button to open the program.

In the following section, I will describe the subjects' computer experience in the icon-recognition test and the navigation test.

Procedure 1: Icon-recognition Test

The ability to recognize icons may be related to the subjects' experience in using icons in different computer environments, such as those mentioned above. The following table shows the computer experience of the subjects in different computer environments.

Table 3. Experience of the subjects with various computer environments.

Operating system	**Means of computer experience (year)**
DOS	5.00
Windows™	3.03
Macintosh™	0.82

A total of 34 subjects participated in the icon-recognition test, of which 24 were males and 10 were females. The average age of the subjects was 25.5, and the range was from 20 to 36. Table 4 below shows the distributions of the colleges of the subjects.

Table 4. Distributions of the colleges of the subjects in the icon-recognition test.

College	**Number of subjects**
Engineering	19
Business	9
Arts & Sciences	6
Total	34

These subjects came from a variety of disciplines so they would allow me to apply and generalize my results to a broad range of computer users.

Procedure 2: Navigation Test

A total of 56 subjects participated in the navigation test, with 27 in the icon group and 29 in the word group. As mentioned previously, none of the 56 subjects participated in the icon-recognition test and none of them was in both groups. I discarded the data of one subject in the icon group because her results greatly deviated from others and significantly affected the outcome of the entire navigation test. See the explanations in the "Discarding one subject" on page 89 in the Results and Discussion section. The subsequent results and analyses do not include this subject. Table 5 below (excluding the subject) shows the distributions of the colleges of the subjects in the icon and word groups.

Table 5. Distributions of the colleges of the subjects in the icon and word groups.

College	**NO. of subjects in the icon group**	**NO. of subjects in the word group**
Engineering	12	14
Business	8	7
Arts & Sciences	6	6
Other	1	2
Total	27	29

As shown in Table 5, the samples in the icon group and in the word group had similar representations from the three colleges, i.e., Engineering, Business, and Arts and Sciences. Because subjects in the same college are more likely to have similar educational and computer backgrounds, the samples should provide two groups of subjects with similar computer backgrounds to compare the test results. The following summarizes the demographics and the computer experience of the subjects.

The icon group consisted of 16 males and 12 females, and the word group consisted of 15 male and 14 females. The average age of the icon group was 23.63 and the average age of the word group was 23.33.

Table 6 compares the average years of experience with DOS in the icon group and the word group.

Table 6. Comparison of the average years of experience with DOS in the icon group and the word group by college.

Group	Mean(yr.)	Standard deviation	prob>|T|
Icon	4.17	2.04	0.378
Word	3.67	2.11	

The table shows that the subjects' average years of experience with DOS in the icon group was 4.17 years and that the subjects' average years of experience with DOS in the word group was 3.67 years. The t-test results indicate that the difference in DOS experience in the two groups is not significant, with the alpha decision level set at $\alpha < 0.05$.

The Windows™ operating system uses a graphical interface. Those subjects who used this operating system had prior experience with icons. Table 7 compares the average years of experience with Windows™ in the icon group and the word group.

Table 7. Comparison of the average years of experience with Windows™ in the icon group and the word group.

Group	Mean(yr.)	Standard deviation	prob>|T|
Icon	2.17	1.16	0.268
Word	2.60	1.72	

In the above table, the t-test results show that the difference in Windows™ experience in the two groups is not significant, meaning that the icon group and the word group had similar experience with Windows™ and hence neither group gains advantage over the other in terms of using icons.

The Macintosh computer also uses a graphical user interface. For instance, the interface uses the trash can icon for deleting a file. Of the 57 subjects in the navigation test, only 3 subjects used the Macintosh operating system, with 2 in the icon group and 1 in the word group. Conducting a t-test with these statistics shows no significant difference in Macintosh experience in the icon and word group.

The similarity of the subjects' computer experience with operating systems is important because subjects with more computer experience may perform better on a computer test like the navigation test.

Collecting Data

In the following sections, I discuss the criteria I used to identify effective icons on the icon-recognition test and the way I measured times on the navigation test.

Determining Effective Icons on the Icon-recognition Test

To be effective, an icon should invoke similar responses in most people, regardless of their background, education, or nationality (Jervell 1985). On the icon-recognition test, I chose those icons whose intended meanings more than 80 percent of the subjects gave. The intended meanings were the ones that I would use to design the icon version of the hypertext program. If they gave a guess different from the one I intended, the guess would be "incorrect."

On the icon-recognition test, some of the icons could have more than one meaning, and all these meanings might be relevant. For instance, an icon showing a pair of glasses may adequately represent an optical store or an optometrist. Both meanings were acceptable for this icon.

However, I intended to use this icon for an optical store on the navigation test, so meanings other than "optical store" were considered inappropriate on the icon-recognition test.

Measuring Travel Times in the Navigation Test

To measure the time a subject needed to travel from one store to another in the mall, I used HyperTalk, a simple computer language, to write a script. This language allowed me to customize the hypertext program for my particular needs. The script measured the time between two mouse clicks. For instance, to measure the time going from store A to store B, a question would ask subjects to use the mouse to click on store A and then store B as soon as they found it. Using the hypertext program to measure the times is more accurate than using a timing device, such as a stop watch.

Analysis

The following section describes the methods I used to analyze the results of the icon-recognition test and the navigation test.

Procedure 1: Icon-Recognition Test

I tabulated the percentage of the subjects who guessed correctly the intended meaning of each icon. I chose those icons in which the highest percentages, or at least 80 percent, of the subjects correctly guessed for designing the icon version of the hypertext program.

Also, I evaluated effectiveness of the icons on the icon-recognition test based on attributes of effective icons Horton discusses (see the section on "Research on Icons" on page 40 and following). This analysis was important because technical communicators need to have guidelines for generating effective icons if my research proved the iconic user interface to be more effective than the textual interface.

Procedure 2: Navigation Test

I compared the times subjects used to complete tasks in the icon version to the times subjects used to complete tasks in the word version. I conducted t-tests on the data I obtained to determine which version enabled the subjects to complete the tasks more efficiently.

Summary

To examine the research question that a hypertext program using icons could help users navigate more effectively than a hypertext program using words, I planned to conduct an empirical study that consisted of two procedures: the icon-recognition test and the navigation test. Thirty-four subjects participated in the icon-recognition test. I had the subjects guess the meanings of 54 icons. From the results, I chose the icons for which more than 80 percent of the subjects guessed correctly the intended meanings, and I used these icons to design the navigation test.

Fifty-six subjects participated in the navigation test: Twenty-seven in the icon group and twenty-nine in the word group. The computer experience of these two groups was similar in terms of average years of experience with different operating systems. I had the icon group attempt the icon version of the test, and the word group attempt the word version. I measured the times the subjects in these two groups used to complete the tasks I assigned to them.

CHAPTER 4: RESULTS AND DISCUSSION

Chapter 4: Results and Discussion describes the data I have collected in the two procedures of my empirical study, i.e., the icon-recognition test and the navigation test, as well as discusses the data. The results of the icon-recognition test allowed me to choose those icons whose intended meanings a majority of the subjects correctly guessed. The navigation test allowed me to determine whether the icon or word version of the hypertext program was more effective in helping subjects search for correct information.

Results of the Icon-Recognition Test

The icon-recognition test examined the effectiveness of the icons I designed. An effective icon should allow a high percentage of subjects to decode its intended meaning or meanings correctly. As mentioned in Chapter 3: Methodology, the intended meanings are those I would use for the navigation test to represent the stores in the mall.

I chose icons that had at least 80 percent of the subjects who correctly guessed their intended meanings. Of the 54 icons, 38 had met this requirement. This many icons were sufficient for me to design the icon version of the hypertext program because I needed only 31 icons to represent all the stores in the shopping mall.

The results of the icon-recognition test allowed me to identify the icons that were effective to represent their intended meanings. Most importantly, this test allowed me to discard icons that were not effective to represent their intended meanings.

In some icons, more than one answer was acceptable, for instance, icon #2 could mean a computer store and an electronics store because some electronics stores, such as Radio Shack, carry computers in addition to other electronic items. Another example is icon #6, represented by a money bag, could mean a bank as well as an ATM machine.

The following table shows the percentages of subjects guessing the correct answer and the number of icons within the range of the percentages.

Table 8. Percentages of subjects guessing correctly verses number of icons.

Percentage of subjects guessing correctly	Number of icons
100%	3
90 - 99%	19
80 - 89%	16
70 - 79%	3
60 - 69%	2
below 59%	11

I did not choose all the icons whose meanings more than 80 percent of the subjects guessed correctly because I needed only 31 icons to design the hypertext program. A total of 38 icons met this criterion, so I discarded 7 qualified icons because I chose other icons that had higher or equal percentages of recognition. For example, I discarded icon #27 (a restaurant) and icon #24 (a bar) because I chose to use icon #29 (a coffee shop), which had the highest percentage (94.11%) of subjects guessing it correctly among the three. I did not want to use all three of them in the hypertext program because they were all related to food establishments, and I wanted to have a variety of stores in the program.

Appendix C shows the percentages of the subjects who guessed correctly the intended meanings. The icons with asterisks are the 31 icons I chose to design the hypertext program for the navigation test.

Discussing Results of the Icon-recognition Test

Before conducting the test, I believed that some icons represented their intended meanings more effectively than the others. However, I intended to see how the subjects on the icon-recognition tests reacted to both effective and ineffective icons. Based on the attributes of effective icons I have previously discussed, I will explain why some icons on the icon-recognition tests were effective and some were not. Because I did not interview the subjects for their comments on each icon, this discussion is based on the results of the test. Although the icon-recognition test was intended to find out the effective icons, it is worthwhile to discuss the attributes of effective icons. Technical communicators may use these attributes to create effective icons.

Examples of Effective Icons

On the icon-recognition tests, the subjects identified the mailbox icon (#38) to be effective because all the subjects gave an acceptable answer such as a post office or a mail box. Based on the results, I assume that this icon carried the attributes of effective icons discussed in Chapter 2: Literature Review -- they were unambiguous, familiar, and legible. To use the notion of articulatory distance discussed in Chapter 2: Literature Review, the articulatory distances of the post office/mail box icon is 100 percent. This percentage indicates that the interpreters' meanings of the icons coincide with the authors' meanings of the icons, as shown in Figure 12.

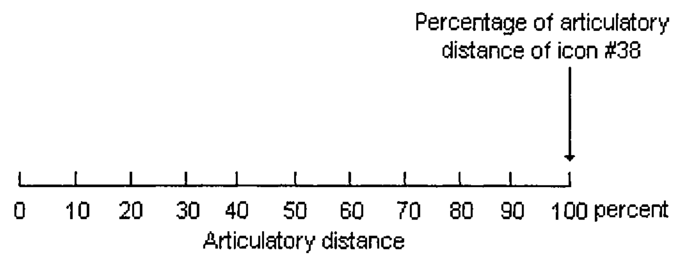


Figure 12. Percentage of the articulatory distance of icon #38

Examples of Poor Icons

A poor icon is one that does not readily communicate its intended meaning to the reader. The icon may be ambiguous, illegible, or unfamiliar to the reader.

Ambiguous Icons

An ambiguous icon is one that carries more than one meaning. The subjects found some of the icons I designed to be ambiguous. For instance, icon #20 could represent a carpet store or a wall paper store because the icon showed a roll of material that could be carpet or wall paper. Only 52.94 percent of the subjects identified it as a carpet store, 38.24 percent of the subjects identified it as a wall-paper store, and 8.82 percent did not attempt this question.

To use the notion of articulatory distance, the articulatory distance of icon #20 is 52.94 percent because

I intended to use this icon for a carpet store. However, the result indicates that there was another competing answer "a wall paper" store, which amounts to 38.24 percent. In other words, about 4 of 10 people guessed that the icon represented a carpet store and about 5 people guessed that the icon represented a wall paper store. When icons show articulatory distances that are so close or that show a difference of 10 percent, the icon is ambiguous. Ten percent is an arbitrary value, and researchers may need to conduct experiments to find the appropriate value to indicate the ambiguity of an icon.

Figure 13 indicates the two percentages of articulatory distance of icon #20.

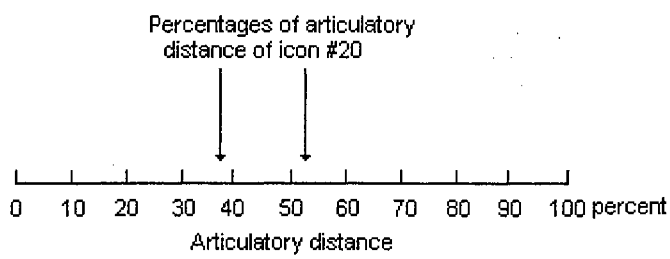


Figure 13. Percentage of articulatory distance of icon #20

The distance between the two arrows indicates the degree of ambiguity of the icon. The closer they are, the more ambiguous the icon is.

Illegible Icons

Pictures displayed on the screen lose resolution. Although I had all the icons printed, some icons were still not legible on paper. One example is the wok icon (#23), which did not show clearly what it was supposed to represent. I intended to use it for a Chinese restaurant. Only 11.76 percent of the subjects correctly guessed its meaning; 32.36 percent interpreted it as a funnel, a pottery shop, or a lighting shop; and 55.88 percent did not attempt this question. Although I do not know the exact reason that they did not attempt the icon, I believe that they might have been able to guess the correct answer if the icon had shown more detail.

To use the notion of articulatory distance, the articulatory distance of the wok icon is 11.76 percent, as shown in Figure 14.

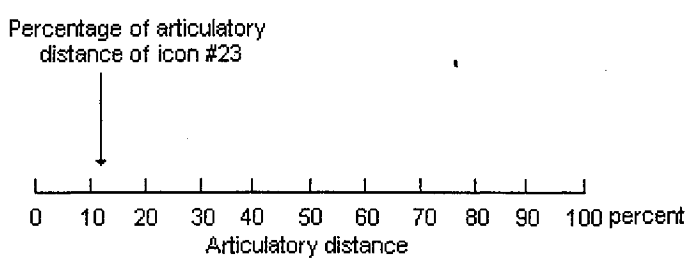


Figure 14. Percentage of articulatory distance of icon #23

This percentage means that this icon is not effective to represent its intended meaning because the percentage indicates about one out of 10 people could recognize its meaning correctly.

Unfamiliar Icons

Some icons were not familiar to the subjects. For instance, only 55.88 percent of the subjects could associate icon #30 with money exchange; 10.81 percent identified it as a bank; and 33.31 percent did not attempt this question. In fact, the money exchange symbol is an international symbol. Those subjects who did not travel often might find this icon new to them. The cultural background of the subjects might have affected their ability to interpret the icon because the icon showed other foreign currencies: the Yen and the British pound. The subjects who were not familiar with foreign currencies may have difficulty deciphering this icon.

To use the notion of articulatory distance, the articulatory distance of icon #30 is 55.88 percent. This percentage means that this icon is not effective to represent its intended meaning because the percentage indicates about 5 out of 10 people could recognize its meaning correctly.

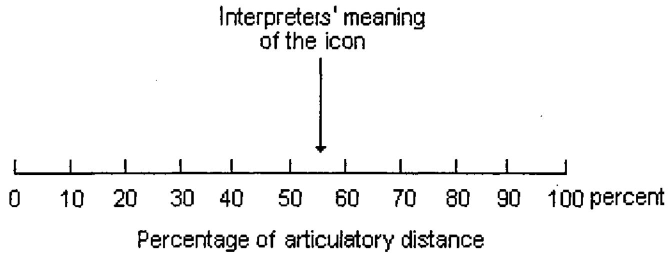


Figure 15. Percentage of articulatory distance of icon #30

The Icon Interpreter

The user who acts as an interpreter plays a vital role in decoding the meaning of an icon (Familant and Detweiler 1993). Factors that influence the way perceivers decode an icon include their educational level and cultural background. Technical communicators need to be aware of how icon users interpret icons (Horton 1994). They need to find what symbols, objects, and concepts are already familiar to them. For instance, not every American family has a wok in their kitchen; therefore, the wok icon (icon #23) may not immediately invoke its intended meanings. Or a mechanic may be more sensitive to tools, such as a wrench (icon #21), than someone who seldom uses tools.

Overall, the icon-recognition test allowed me to select 31 icons to design the icon version of the hypertext program for the navigation test. It also allowed me to apply attributes of effective icons to analyze the results of the icon-recognition test. To be effective, icons have to be unambiguous, familiar, and legible to the icon interpreter.

The primary objective of the icon-recognition test was find the icons that more than 80 percent of the subjects identified their meanings correctly. Based on the results, I could guess the reasons why subjects did not identify an icon correctly. To have statistical support for my analysis, I needed more data from the subjects. For example, if I had asked each subject questions about their guesses, I would have accounted for the effectiveness of the icons more accurately.

Results and Discussion of the Navigation Test

In the following sections, I will explain why I discarded one subject in the icon group whose results deviated from all other subjects in her group. Also, I will summarize the results of exercises 1, 2, and 3 on the navigation test.

Discarding One Subject

A total of 28 subjects in the icon group participated in the navigation test. However, one of them took a longer time to complete the tasks on the second try (i.e., in exercise 3) than on the first try. This one subject used 100 seconds to complete exercise 1, and 131 seconds to complete exercise 3, i.e., an increase of 31 seconds on the second try. Table 9 below shows the subject's results of the six problems on the navigation test.

Table 9. Results of the six problems on the navigation test for the subject.

Problem #	First try (seconds)	Second try (seconds)
1	9	22
2	12	16
3	20	24
4	25	29
5	17	23
6	17	17
Total	100	131

All the other subjects in the icon group shortened their completion times on the second try, ranging from 1 to 31 seconds, and only this particular subject did not shorten the completion time on the second try.

I observed that this subject, from the College of Arts and Sciences, was confused with the left and right directions. She had to back-track his path and hence lost many seconds. Because her results were not representative of those of the groups as a whole, they skewed the overall means and standard deviations. Given her unusual difficulty in interpreting the directions of the task, I decided to discard this subject's data. All statistical analyses that follow do not include the subject's data.

Exercise 1

Exercise 1 of the navigation test examined the question that a hypertext program using icons could help users navigate more effectively than a hypertext program using words, under the condition that subjects did not have prior knowledge of the icons on the test (condition 1). The exercise required 27 subjects in the icon group and 29 subjects in the word group to complete all six problems in the same sequence, each of which asked the subjects to go from one store to another. When I observed that a subject failed to locate an icon or located an incorrect one, I would tell the subject what the correct icon was. Occasionally, I found that subjects identified or located an incorrect icon. I will describe these cases later in this section.

The overall results of Exercise 1 show no significant difference between the time the icon group used to complete all six problems and the time the word group used to complete the same problems (0.14 at $p < 0.05$). The observed critical value $t_{observed}$ (1.50) did not exceed the critical value $t_{critical}$ (1.684). Table 10 below shows the t-test results of the navigation tests the icon group and the word group performed.

Table 10. T-test results of navigation test (exercise 1).

Problem number	Group	Mean (seconds)	Standard deviation	T-test value	Prob>|T|
1	icon	9.59	1.58	1.17	0.24
	word	10.14	1.88		
2	icon	14.15	3.84	0.23	0.81
	word	13.93	3.12		
3	icon	13.00	2.09	3.15	0.003
	word	15.00	2.63		
4	icon	16.33	5.22	0.59	0.55
	word	15.65	2.81		
5	icon	15.89	2.55	1.94	0.06
	word	17.12	2.25		
6	icon	12.44	2.53	1.93	0.06
	word	13.82	2.81		
Average	icon	81.70	10.9	1.50	0.14
	word	85.69	8.7		

Problem 1

Problem 1 asked the subjects to go from the optical store on the first floor of the main lobby to the barber shop on the first floor of the right wing. All subjects in both the icon group and the word group started from the first floor of the main lobby. To find the target icon, i.e., the barber shop icon, a subject in the icon group would have to click on the right arrow button at the bottom of the screen to go to the right wing of the first floor. Then the subject had to locate the appropriate store and click on it.

Because Table 10 indicates that the means of the icon group and the word group are 9.59 seconds and 10.14 seconds, respectively, the icon group completed the task

0.55 second faster than the word group. However, the difference between the completion times in both groups is not significant (0.24 at $p < 0.05$). As I observed the subjects performing this problem, I did not see the subjects in either group having difficulty locating the barber shop icon or the "barber shop" label.

Problem 2

Problem 2 asked the subjects to go from the baby supply store on the first floor of the right wing to the bank on the first floor of the left wing. In the icon version, the bank is represented by a money bag with a dollar sign ($) on it. In the word version, the bank is represented by the "bank" label.

Because Table 10 indicates that the means of the icon group and the word group are 14.15 seconds and 13.93 seconds, respectively, the icon group completed the task 0.22 second slower than the word group. However, the difference between the completion times in both groups is not significant (0.81 at $p < 0.05$).

Problem 3

Problem 3 asked the subjects to go from the travel agent on the first floor of the left wing to the florist on the second floor of the main lobby. The florist is represented by an icon showing a plant. Because Table 10 indicates that the means of the icon group and the word group are 13.00 seconds and 15.00 seconds, the icon group completed the task 2.00 second faster than the word group. The difference was significant because the probability was 0.003, which was less than the set alpha decision level, i.e., 0.05.

The significance is attributed to the concreteness of the icon. Because the problem asked the subjects to buy a plant and the icon directly depicts a plant, the subjects found it easy to interpret the icon. Of the six problems, the icon group completed only this particular task significantly faster than the word group.

Problem 4

Problem 4 asked the subjects to go from the locksmith on the first floor of the main lobby to the tuxedo rental store on the first floor of the right wing. The tuxedo store is represented by an icon showing a tuxedo. As shown in Table 10, the means of the icon group and the word group are 16.33 seconds and 15.65 seconds. In other words, the icon group completed the task 0.68 second slower than the word group. However, the difference between the times in the icon group and the word group was not significant.

Placement of an icon influences a subject's search time. I placed the "tuxedo" icon (#12) together with the "restrooms" icon (#16) on the first floor of the right wing without realizing that the "restroom" icon happened to have a man and a woman, and the man appeared to wear a suit. Four subjects in the icon group clicked on this icon as the "tuxedo" icon. They realized that they made a mistake after they clicked on the wrong icon, resulting in extra time going back to find and click on the correct icon.

In the word version of the hypertext program, the subjects did not have the problem of being distracted by a similar icon because two different labels, "restrooms" and "tuxedo rental," indicated the respective stores.

The standard deviations of the icon group and the word group are 5.22 and 2.81, respectively. Because the standard deviation measures the average of how far the subjects in a group varied from the mean, the higher standard deviation of the icon group indicates that the average of the completion times in the icon group varied from the mean more than the average of the completion times in the word group. Thus, the word group is more homogeneous than the icon group in terms of the times used to complete this problem.

Problem 5

Problem 5 asked the subjects to go from the music store on the first floor of the right wing to the coffee shop on the second floor of the left wing. Because Table 10 indicates that the means of the icon group and the word group are 15.89 seconds and 17.12 seconds, the icon group completed the task 1.23 seconds faster than the word group. However, the difference between the times in the icon group and the word group is still not significant (0.06 at $p < 0.05$), although it is close to being significant.

Problem 6

Problem 6 asked the subjects to go from the fishing store on the second floor of the left wing to the camera store on the first floor of the main lobby. Because Table 10 indicates that the means of the icon group and the word group are 12.44 seconds and 13.82 seconds, the icon group completed the task 1.38 seconds faster than the word group. However, the difference between the times in the icon group and the word group is still not significant (0.06 at $p < 0.05$), although it is close to being significant.

General Discussion of Exercise 1

Although the results indicate that icons were not more effective than words in helping users navigate in a hypertext program, two observations are useful for further research on using icons in hypertext programs. One is that the icons that earned high percentages of recognition did not show higher degrees of effectiveness on the navigation test than the icons that earned low percentages of recognition. The other is that icons using "direct" pictures prove to be more effective in helping users locate information than icons using "indirect" pictures. I will define direct and indirect pictures in the section where I explain the observation.

Of the icons chosen for the navigation test, the icons that earned high percentages of recognition did not show higher degrees of effectiveness on the navigation test than the icons that earned low percentages of recognition. For instance, the plant icon in problem 3 earned 88 percent of recognition on the icon-recognition test, and the icon group completed this problem significantly faster than the word group, as the possibility value (0.003) indicated. Other icons, such as the bank icon (97%), the coffee shop icon (92%), and the camera shop icon (97%), earned higher percentages of recognition than that of the plant icon. However, in the problems using these icons, the icon group did not complete the problems significantly faster than the word group. I believe that the icons that earned higher percentages of recognition did not necessarily prove to be more effective than the icons that earned lower percentages. The reason is that the icon-recognition tested how well subjects recognized the meanings of the icons, but not how fast they identified the icons or how fast they identified them in a hypertext environment. Because the results of the icon-recognition test did not correlate to those of the navigation test, I analyzed the results of the navigation test independent of the icon-recognition test.

In summary, Exercise 1 shows no significant difference between the time the icon group used to complete the six problems and the time the word group used to complete the same problem, although the overall mean of the icon group is lower than that of the word group. The icon group performed better in the last two problems because the probability values were close to being significant. This result may be attributed to the subjects getting familiar with using the shopping mall program.

Exercise 3

In reporting the results, I skip directly to exercise 3 because exercise 3 had the subjects in the word group and the icon group repeat exercise 1. I will discuss Exercise 2 in the next section. Exercise 3 examined the research question that a hypertext program using icons could help users navigate more effectively than a hypertext program using words, given that subjects had prior knowledge of the icons on the test and that they had experience of using the hypertext program to locate information.
Table 11 shows the results of this exercise and the t-test.

Table 11. T-test results of the navigation test (exercise 3).

Problem number	Group	Mean	Standard deviation	T-test value	Prob>|T|
1	icon	8.63	1.45	2.05	0.04
	word	9.40	1.66		
2	icon	11.18	2.60	1.88	0.06
	word	12.40	2.54		
3	icon	11.11	1.65	2.47	0.02
	word	12.50	2.54		
4	icon	11.81	1.86	2.75	0.01
	word	13.55	2.79		
5	icon	13.67	2.29	2.23	0.03
	word	15.58	3.96		
6	icon	10.25	2.12	2.15	0.04
	word	11.31	1.44		
Average	icon	66.67	6.12	3.92	0.003
	word	74.86	9.31		

Because the average time the subjects in the icon group took to finish all six problems was 66.67 seconds and the subjects in the word group was 74.86 seconds, the difference is 8.19 seconds. The difference was significant (0.003 at $p < 0.05$). The observed critical value $t_{observed}$ (3.92) exceeded the critical value $t_{critical}$ (1.684).

As shown in Table 11, the icon group completed all the six problems, except problem 2, significantly faster than the word group. Although the icon group was not faster than the word group in problem 2 (0.06 at $p < 0.05$), it was very close to being significantly faster than the word group.

Problem 2 asked the subjects to go from the baby supply store on the first floor of the right wing to the bank on the first floor of the left wing. In exercise 1, the icon group completed the task 0.22 seconds slower than the word group. In this exercise where they repeated Problem 2, the icon group completed the task 1.22 seconds faster than the word group. In other words, the icon group on the second try improved by 1.44 seconds, although the possibility value (0.06) shows it was not significant, it is very close to being significant. The improvement in time indicates that having recognized the meaning of the bank icon helps the subjects in the icon group find information faster. Although the difference is not significant in this problem, the results of all other problems show significant improvement of the icon group.

From my observations, the subjects in the icon group and the word group navigated in the mall on the second try more easily than they did on the first try. The subjects in the icon group had no difficulty recognizing the icons on the second try, and those in the word group also recognized the stores they needed to locate to complete the tasks. The subjects who had problems in exercise 1 did not encountered the same problems. For instance, in problem 4, the subjects who took the restroom icon for the tuxedo rental store did not make the same mistake. The icon group completed this problem significantly faster than the word group, as the probability value (0.01) indicates. Having knowledge of the icons helped the subjects locate information they needed.

The major result of this exercise is that the icon version of the hypertext program is more effective than the word version after the subjects have become familiar with the icons they wanted to locate and with using the hypertext program. My findings in this exercise support Paivio's theory (Paivio 1971; Paivio 1986; Paivio 1991) that pictures are likely to be spontaneously named, resulting in two memory traces instead of one. Words may be similarly dually encoded, but is less likely to occur spontaneously. The result that the icon group completed the tasks faster than the word group after the icon group was familiar with the icons supports his notion. Because of this superiority of pictures, the subjects in the icon group retrieved the icons faster than the subjects in the word group retrieved the word equivalents. When the subjects in the icon group attempted the tasks on the second try, they were familiar with the icons they wanted to locate. This familiarity promotes dual coding (Paivio 1972; Hordes 1992) and therefore helps the subjects in the icon group to recall the icons.

General Discussion of Exercise 3

As mentioned in the previous section, the overall result of the icon group finished the tasks faster than the word group. This result is more likely to be attributed to the effect of the icons than other factors, such as the familiarity of the hypertext program and of the icons. As mentioned in Chapter 3: Methodology, both the icon version and the word version of the hypertext program were identical in terms of, for example, the overall layout of the mall, the locations of the stores, and the number of floors and wings. The major difference between the two versions is that the icon version used icons to represent the stores and the word version used words to represent the stores, so any difference in performance between the two groups should be attributed to using different methods (icon vs word) to represent the stores. After completing exercise 1, the icon group should become familiar with the hypertext program as much as the word group because of the similar settings of the two versions. Therefore, neither group gained any advantage over the other as a result of becoming familiar with using the program. It is unlikely that the icon group finished the tasks faster than the word group because the icon group became familiar with the program.

One may also argue that the icon group completed the tasks faster than the word group because the icon group had more computer experience than the word group. This argument is not valid because Table 4 and Table 5 (on pages 72 and 73 respectively) in Chapter 3: Methodology compare the computer experience in these two groups. The results indicate that the computer experience in both groups is not statistically significant. Therefore, neither group gained any advantage over the other in terms of computer experience. It is unlikely that the icon group finished the tasks faster than the word group because the icon group had more experience than the word group. The result that the icon group performed better should be attributed to using different methods (icon vs word) to represent the stores.

Exercise 2

Exercise 2 examined the research question whether a hypertext program using icons could help users search for needed information more effectively than a hypertext program using words under the condition that the subjects had become familiar with the icons in the hypertext program and had used the hypertext program. This exercise used the same subjects who participated in exercise 1. The icon group used the icon version of the hypertext program, and the word group used the word version. Having used the program in exercise 1 means that subjects were familiar with the way of searching information.

Exercise 2 asked the subjects to complete a series of tasks consecutively. The subjects needed to locate five stores, i.e., a phone booth, a bicycle store, a golf store, an electronic store, and a post office. The hypertext program automatically recorded the total times they needed to locate the five stores. This exercise tried to simulate a situation in which users go through a sequence of steps to look for information they need. Also, the subjects in the icon and the word groups knew how to use the hypertext program to find information, although they did not know the meanings of the icons used in this exercise. Table 12 below shows the results of exercise 2.

Table 12. Comparison of the times the icon group and the word group took to complete the shopping list.

Group	Mean	Standard deviation	T-test value	Prob>|T|
icon	36.76	7.01	1.94	0.06
word	40.73	8.71		

Because Table 12 indicates that the means of the icon group and the word group are 36.76 and 40.73 seconds, respectively, the icon group completed the task 3.53 seconds faster that the word group. However, the difference is not significant (0.06 at $p < 0.05$).

The results in this exercise were similar to the results of exercise 1, in which the subjects attempted to find the icons for the first time. The icon version was not more effective than the word version in helping the subjects navigate in the hypertext program. However, the results were close to being significant, as indicated by the probability value of 0.06. As I observed the subjects in the icon and word groups performing the exercise, I did not find that they had problems locating the icons or the word labels. They seemed to be more familiar with the shopping mall setting and to navigate more at ease than they did in exercise 1.

Paivio's dual coding theory does not apply to exercise 2 because this theory contends that a person sees a pictures and generates two codes. Because the subjects saw the icons in exercise 2 for the first time, they had not yet formed any codes of the object.

Exercise 3 also has an important implication. Although the subjects in the icon group had used the hypertext program, the icons in the program still played a major role in helping them locate needed information. The icon group was familiar with using the hypertext program, but had not seen the icons that represented the stores they wanted to locate. The results indicate that the icon group did not complete the exercise faster than the word group.

Limitations of the Results

Like many other empirical studies, the results I have found have limitations. This section points out the particular hypertext program I designed and the subjects I chose may limit the applications of the results.

Program

The hypertext program I designed for the navigation tests had six screens, each of which connected to the "neighboring" screens by hypertext links. Through my observations, the subjects did not have difficulty navigating through the program. After the test, I asked subjects about how easily they traveled in this program.

Almost all subjects, including those who made mistakes in the navigation tests, said it was easy to use. However, many hypertext programs, such as an information database on the World Wide Web or in an electronic encyclopedia, have many more links than the program I have designed. Users might not be able to create a spatial orientation as easily as the subjects who visited the hypertext shopping mall. As the amount of information increases, users will have difficulty locating information.

In addition, the majority of icons I used in the icon version of the hypertext program were concrete objects. For instance, I used the glasses icon to represent an optical store. Research has shown that concrete words were recognized or recalled better than abstract words (Gorman 1961; Paivio et al. 1969). Also, icons may not represent abstract ideas as effectively as they represent concrete objects. Designing an iconic menu is a difficult task when the application requires using abstract or semiabstract categories (Barfield et al 1991). Researchers need to conduct more studies to see if icons can represent abstract ideas as effectively as concrete objects in hypertext environments.

Subjects

Validity in the generalizabily of any finding in a research setting increases with the sample size (Holleran 1991). The subjects in my research were all college students; however, computer users consist of people from different disciplines (Cusack 1993). In an empirical study, it is difficult to find subjects who have all the characteristics of a typical computer user. As Martin (1991) indicates, the application developer must take into account the differences in the information processing capabilities of people and computers. Researchers may want to study how people with different educational levels, ages, and computer experiences benefit from a program using an iconic user interface.

Summary

In this "Results and Discussion" chapter, I have described and explained the results I have found on the navigation tests under the three conditions. The subjects in the icon group did not complete the tasks faster than the subjects in the word group under the condition that they did not know the meanings of the icons used in the hypertext program (condition 1). However, after they had learned the meanings of the icons (condition 3), the icon group completed the tasks faster than the word group. According to Paivio's dual coding theory, the subjects in the icon group memorized graphics better than text.

When a test question asked the subjects to consecutively locate a number of stores, the subjects in the icon group did not complete the problem significantly faster than those in the word group, although the results were close to being significant. The subjects in the icon group were familiar with using the hypertext program, but had not learned the meanings of the icons in the hypertext program (condition 2).

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

The research question I set out to answer was whether using icons is an effective navigation aids in hypertext under three conditions. To answer this question, I compared the effectiveness of icons to that of words in hypertext. I found that if the subjects were not familiar with the icons and the program (condition 1), the icon version was not more effective than the word version. If the subjects were familiar with using the program but not the icons (condition 2), the icon version was not more effective than the word version. Icons were effective navigation aids only under the condition that the subjects in the icon group were familiar with the icons in the hypertext program and familiar with using the hypertext program (condition 3). To interpret the results, I used Paivio's dual coding theory, which claims that pictures generate two codes more readily than words and therefore help subjects memorize the icons.

The significance of this research is that I provided empirical evidence for using icons in designing user interfaces for programs users use more than one time. Although the results indicate that icons do not help users navigate in hypertext when they were not familiar with the icons, users can still benefit from many programs that they may use more than one time. Examples of such programs are shopping mall web sites, databases that provides users with options to choose from, and online help systems.

For testing purposes, the icon version of the hypertext program in this study includes only icons without text. However, if users need to go through a series of menus to locate information, implementing icons on these menus will help users navigate to the node where they can find information they need. As database programs rapidly expand to accommodate increasing amounts of information, it becomes necessary for technical communicators to design a series of menus, similar to the format I used for the shopping mall program, to help users navigate and search for information they need. Again, this application is relevant to programs users may need to re-use.

The iconic interface is currently an unspoken standard in computer interface design, but research in this area is scarce. With the results I found in this research, technical communicators have empirical support to using icons to help users navigate and locate needed information for programs users may need to use again.

To generalize the results I have found in this study, researchers may want to conduct further studies in the following areas.

- Researchers may want to study the effect of icons on helping users navigate in a hypertext program in a long period of time, for example, a month or a school semester. Lengthening the test period would generate results relevant to hypertext programs users repeatedly use in a long period of time.
- Researchers may want to use subjects from various education levels and with computer backgrounds so that results can apply to a wider scope of audience. My research subjects are limited to college students, and the results can only apply to users who have similar backgrounds and educational levels of college students.
- Researchers may study computer programs in different environments other than a shopping mall environment to see whether the results hold true in other environments, such as large databases and multimedia tutorials.

Because I find that icons are more effective words after users have learned their meanings, I recommend that technical communicators use icons to help users navigate in a hypertext program if the users are likely to re-use the program. After the users have used the program and become familiar with the icons, these icons will help them navigate effectively in the program.

Also, I recommend that technical communicators design easy-to-learn icons for hypertext programs users use more than one time. To help users easily learn the meaning of an icon, technical communicators should adhere to the guidelines for designing effective icons I used to analyze the effectiveness of icons in Chapter 3: Methodology. Effective icons are those that are unambiguous, legible, and familiar to users. Technical communicators should generate a set of standard icons, such as international travel signs at airports and hotels, and encourage hypertext authors to implement them in online database programs. Users can quickly learn the meanings of the icons and hence benefit from using these icons to find information they need.

This dissertation is only an initial attempt to solve the problem of navigation in hypertext programs. New ways of presenting online information may generate other navigation problems of which researchers may not be aware. For example, technical communicators can use tables or multiple columns to present information on a World Wide Web page. Researchers need to continue to explore possible ways to help users quickly find information they need in hypertext programs.

REFERENCES

Aksyn, R., D. McCracken, and E. Yoder. 1988. KMS, a distributed system for managing knowledge in organizations. *Communications of the ACM*. July: 820-835.

Arend, U., K. P. Utthig, and J. Wandmacher. 1987. Evidence for global feature superiority in menu selection by icons. *Behaviour and Information Technology* 6 (4): 411-426.

Banks, W. P. and J. Flora. 1977. Semantic and perceptual processes in symbolic comparisons. *Journal of Experimental Psychology: Human Perception and Performance*. 3: 278-290.

Barfield, W., C. Rosenberg, and G. Levasseur. The use of icons, earcons, and commands in the design of an online hierarchical menu. *IEEE Transactions on Professional Communication*. 34 (2): 101-108.

Benbasat, I., and P. Todd. 1993. An experimental investigation of interface design alternatives: icon vs. text and direct manipulation vs. menus. *International Journal of Man-Machine Studies* 38: 369-402.

Bernstein, M. 1991. Deeply intertwingled hypertext: The navigation problem reconsidered. *Technical communication*. 38 (1): 41-47.

Black, M. 1962. *Models and metaphors: Studies in language and philosophy*. Ithaca, NY: Cornell University.

Blankenberger, S. and K. Hahn. 1991. Effects of icon design on human-computer interaction. *International Journal of Man-Machine Studies*. 35: 363-77.

Burke, K. 1945. *A grammar of motives*. Berkeley, CA: University of California Press.

Bush, V. 1945. As we may think. *Atlantic Monthly*. 176 (July): 101-108.

Carr, C. Hypertext: A new training tool? *Educational Technology*. August: 7-11.

Carroll, J. M., R. L. Mack, and W. A. Kellogg. 1988. Interface metaphors and user interface design. In *Handbook of Human-Computer Interaction*. Ed. M. Helander, 67-85. Amsterdam, Netherlands: Elservier Science Publishers.

Carroll, J. and J. Thomas. 1982. Metaphor and cognitive representation of computing systems. *IEEE Transactions on Systems Man and Cybernetics.* 12(2): 107-116.

Charney, D. 1987. Comprehending non-linear text: The role of discourse cues and reading strategies. *Proceedings HyperTEXT 87*. 109-119.

Conklin, J. 1987. Hypertext: An introduction and survey. *IEEE Computer*. September: 17-41.

Cusack, Michael W. 1993. Efforts to simplify human-computer communication. *IEEE Transactions on Professional Communication* 36. (1): 14-19.

Dewhurst, S. A. and M. A. Conway. 1994. Pictures, images, and recollective experience. *Journal of Experimental Psychology: Learning, Memory and Cognition*. 20 (5) 1088-98.

Edwards, D. M., and L. Hardman. 1989. Lost in hyperspace: Cognitive mapping and navigation in a hypertext environment. In *Hypertext: Theory into practice*, ed. R. McAleese, 105-125. Osney Mead, Oxford, United Kingdom: Blackwell Scientific Publications.

Elm, W. C. and D. D. Woods. 1985. Getting lost: A case study in interface design. *Proceedings of Human Factors Society 29th Annual Meeting*. 927-931.

Engelbart, D. C. 1963. A conceptual framework for the augmentation of man's intellect. *In Vista in information handling*, Vol 1. London, UK: Spartan Books.

Evans, G. E. 1988. Metaphors as learning aids in university lectures. *Journal of Experimental Education*. 56: 91-99.

Familant, M. E., and M. C. Detweiler. 1993. Iconic reference: evolving perspectives and an organizing framework. *International Journal of Man-Machine Studies*. 39: 705-28.

Foss, C. L. 1989. Tools for reading and browsing hypertext. *Information Processing Management*. 25 (4): 407-418.

Gaines, B. R., and M. L. G. Shaw. 1995. Concept maps as hypermedia components. *International Journal of Man-Machine Studies*. 43: 323-61.

Glushko, R. 1989. Design issues for multi-document hypertexts. *Proceedings of Hypertext '89*. Baltimore: ACM: 33-40.

Gorman, A. M. 1961. Recognition memory for nouns as a function of abstractness and frequency. *Journal of Experimental Psychology*. 61: 23-29.

Gribbons, W. M. 1991. Visual literacy in corporate communication: Some implications for information design. *IEEE Transactions on Professional Communication*. 34 (1): 42-50.

Grice, R. A., L. s. Ridgway, and E.J. See. 1991. *Hypertext: Controlling the leaps and bounds. Technical Communication*. 38 (1): 48-56.

Guastello, S. J., and M. Traut. 1989. Verbal versus pictorial representations of objects in human-computer interface. *International Journal of Man-Machine Studies*. 31: 99-120.

Halasz, F. G. 1988. Reflections on NoteCards: Seven issues for the next generation of hypermedia systems. *Communications of the ACM*. (31) 7:836-52.

Hammond, N., and L. Allinson. 1987. The travel metaphor as design principle and training aid for navigating around complex systems. In *People and computers III*, eds. D. Diaper and P. Winder: 75-90. Cambridge: Cambridge University Press.

Hayes, D. A., and R. J. Tierney. 1982. Developing Readers' Knowledge through Analogy. *Reading Research Quarterly*. 18(2): 256-281.

Hodes, C. L. 1992. The effectiveness of mental imagery and visual illustrations: A comparison of two instructional variables. *Journal of Research and Development in Education*. 26(1): 47-57.

Holleran, Patrick A. 1991. A methodological note on pitfalls in usability testing . Journal of Behaviour and Information Technology. 10(5): 345-357.

Holman, H. 1986. *A handbook to literature*. 4th edition. Indianapolis, IN: Bobbs-Merrill Educational Publishing.

Horton, W. 1991. *Illustrating computer documentation: The art of presenting information graphically on paper and online*. John Wiley & Sons, Inc.

Horton, W. K. 1994. *The icon book: Visual symbols for computer systems and documentation*. New York: New York, John Wiley & Sons.

Jervell, H. R., and K. A. Olsen. 1985. Icons in man-machine communications. *Behaviour and Information Technology*. 4 (3): 249-54.

Jonassen, D. H. 1988. Designing structured hypertext and structuring access to hypertext. *Educational Technology*. November: 13-16.

Lakoff, G., and M. Johnson. 1980. *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Langer, S. *Philosophy in a new key: A study in the symbolism of reason, rite, and art*. Cambridge, MA: Harvard University Press.

Lansdale, M. W., M. Simpson, and T. R. M. Stroud. 1990. A comparison of words and icons as external memory aids in an information retrieval task. *Behaviour and Information Technology*. 9: 111-31.

Leedy, P. 1989. *Practical design: Planning and design*. 4th ed. New York, NY: Macmillan Publishing Company.

Li, R. 1993. Creating interactive CBT lessons without video. *Educational Technology*. 33 (5): 20-26.

MacGregor, J. N. 1992. A comparison of the effects of icons and descriptors in videotex menu retrieval. *International Journal of Man-Machine Studies*. 37: 767-777.

Martin, J. 1991. *Systems application architecture: Common user access*. Englewood Cliffs, New Jersey: Prentice Hall.

McKnight, C., A. Dillon, and J. Richardson. 1991. *Hypertext in context*. Cambridge, UK: Cambridge UP.

Muter, P., C. Mayson. 1986. The role of graphics in item selection from menus. *Behaviour and Information Technology*. 5: 89-95.

Nelson, T. H. 1987. *Literary Machines*. South Bend, IN: the Distributors.

Nickerson, R. S. 1965. Short-term memory for complex meaningful visual configurations: a demonstration of capacity. *Canadian Journal of Psychology*. 19: 155-160.

Norton, P., and R. Jourdain. 1990. *Peter Norton's PC problem solver*. New York, New York: Simon & Schuster, Inc.

Ortony, A. 1979. The role of similarity in similes and metaphors. In *Metaphor and Thought*, ed. A. Ortony. New York, Cambridge University Press.

Paivio, A., and K. Csapo. 1969. Concrete image and verbal memory codes. *Journal of Experimental Psychology.* 80: 279-285.

Paivio, A. 1971. *Imagery and verbal processes*. New York: Holt, Rinehart and Winston.

Paivio, A. 1973. Psychophysiological correlates of imagery. In *The psychophysiology of thinking*, eds. J. McGuigan and R. Schoonover. New York: Academic Press.

Paivio, A. 1990. *Mental Representations: A Dual Coding Approach*. New York: Oxford University Press.

Paivio, A. and K. Csapo. 1973. Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology*. 5: 176-206.

Paivio, A. 1991. *Images in mind: The evolution of a theory*. New York: Harvester Wheatsheaf.

Richards, I. A. 1936. *The philosophy of rhetoric*. Oxford, London: Oxford University Press.

Rizk, A., N. Streitz, and J. Andre (eds). 1990. *Hypertext: Concepts, systems and applications*, Proc European Conference on Hypertext INRIA, France, Cambridge University Press, Cambridge.

Rogers, Y. 1989. Icons at the interface: Their usefulness. *Interacting with Computers*. 1: 105-117.

Rubens, Philip. 1991. Reading and employing technical information in hypertext. *Technical communication*. 38 (1): 36-40.

Shepard, R. 1967. Recognition memory for words, sentences and pictures. *Journal of Verbal Learning and Verbal Behavior*. 6: 156-163.

Shirk, H. N., and H. T. Smith. 1994. Some issues influencing computer icon design. *Technical Communication.* 41 (4): 680-89.

Smith, P. A. and J. R. Wilson. 1993. Navigation in hypertext through virtual environments. *Applied Ergonomics*. 24(4): 271-278.

Standing, L., J. Conezio, and R. N. Haber. 1970. Perception and memory for pictures: single trial learning of 2500 visual stimuli. *Psychonomic science*. 19: 73-74.

Tripp, S. D. and W. Roby. 1990. Orientation and Disorientation in a Hypertext Lexicon. *Journal of Computer-Based Instruction*. 14 (4): 120-24.

Tsai, C. 1988-89. Hypertext: Technology, applications, and research issues. *Journal of Educational Technology Systems.* 17(1): 3-14.

Utting K., and N. Yankelovich. 1989. Context and orientation in hypermedia networks. *ACM Transactions on Information Systems.* 7 (1): 58-84.

Vosniadou, S., and M. Schommer. 1988. Explanatory analogies can help children acquire information from expository text. *Journal of Educational Psychology.* 80(4): 524-36.

Wenger, M. J., and D. G. Payne. 1994. Effects of a graphical browser on readers' efficiency in reading hypertext. *Technical Communication*. 41(2): 224-233.

Yankelovich, N., B. J. Hass, N. K. Meyrowitz, and S. M. Drucker. 1989. Intermedia: The Concept and Construction of a Seamless Information Environment. *IEEE Computer.* 21: 91-96.

Yeo, S. C. 1996. Writing for the Web—what is it all about? *Proceedings of the 43rd International Technical Communication Conference*. Arlington, VA: Society for Technical Communication. 364.

APPENDIXES

APPENDIX A: APPROVAL FORM FROM INSTITUTION RESEARCH BOARD

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 10-06-94 **IRB#:** AS-95-014

Proposal Title: RELATIONSHIP OF METAPHOR IN HYPERTEXT DOCUMENTS AND USABILITY

Principal Investigator(s): Thomas Warren, Yu-kwong Chiu

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved with Provisions

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

PROVISIONS REQUESTED:

1. In the oral solicitation, subjects should be told that their participation is voluntary, and that the choice not to complete the questionnaire will not result in a penalty.

2. Because of the nature of the study, a consent form is not required, as it would be the only record linking the subject and the research. Rather, subjects should be given an information letter containing all the elements of informed consent.

DO NOT PROCEED WITH THIS STUDY PRIOR TO RECEIVING FINAL APPROVAL.
Please submit your response to Jennifer Moore, IRB Executive Secretary, 005 LSE, x45700.

If you have any strong disagreements with the reviewer's recommendations, you may respond in writing to the executive secretary or request a meeting with the full IRB to discuss the recommendations.

Signature: John H. Wyckoff Date: October 11, 1994
Chair of Institutional Review Board

APPENDIX B: PRINTOUTS OF THE ELECTRONIC SHOPPING MALL

(the Icon version and the Word versions)

Welcome to Hopewell Mall

(icon version)

Click Arrow to Continue

Instructions for Visiting Hopewell Mall

Please carefully read through the instructions in the following screens before visiting the mall. These instructions will help you travel in this mall.

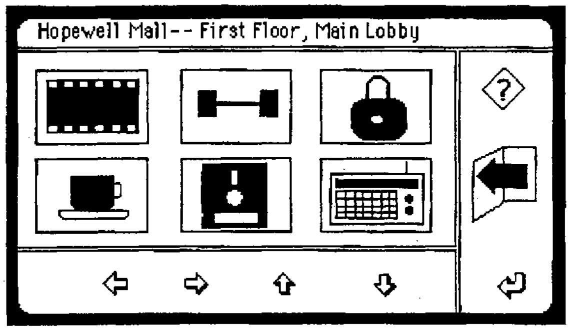
Click on the forward arrow at the bottom center of the screen to go to the next screen.

If you want to go back to the previous screen, click on the bent arrow at the bottom right-hand corner. This arrow appears on every card.

Click Arrow to Continue **Return**

Instructions for Visiting Hopewell Mall

Each time, the screen displays only one section of the floor. For instance, the screen below shows the first floor of the main lobby.

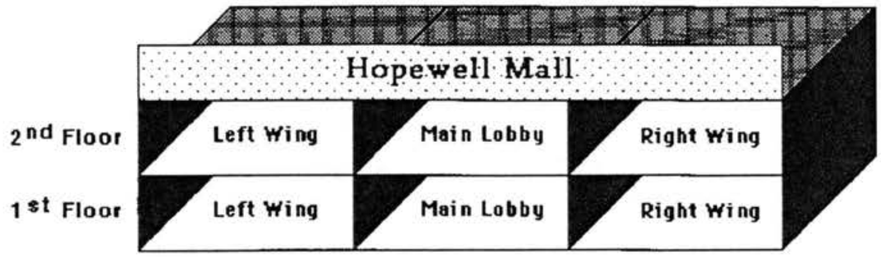


Each of the small pictures represents a different store. For instance, the top left-hand corner one represents a photo processing store. and the one below it represents a coffee shop.

Click Arrow to Continue **Return**

Instructions for Visiting Hopewell Mall

Hopewell Mall consists of two floors. Each floor has three sections: the main lobby, the right wing, and the left wing as shown in the following three-dimensional diagram.

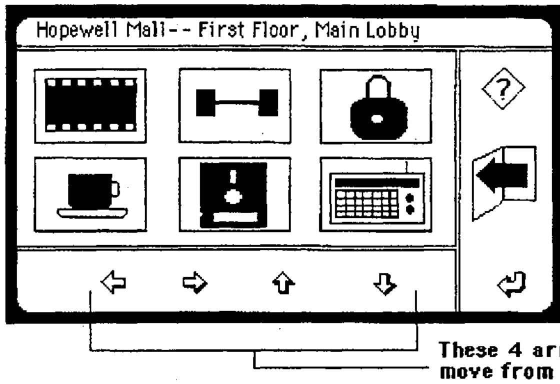


Click Arrow to Continue

Return

Instructions for Visiting Hopewell Mall

You may go around in this mall by using the arrows at the bottom center of the screen. Click on each arrow for further information.



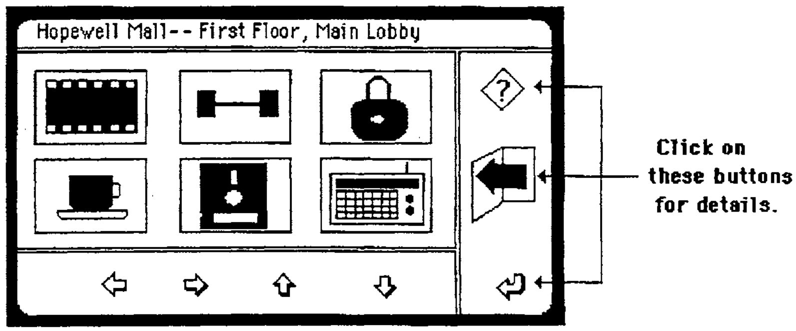
These 4 arrows allow you to move from one screen to another. Click on each one for details.

Click Arrow to Continue

Return

Instructions for Visiting Hopewell Mall

Each screen also displays a Help symbol, an Exit symbol, and a return arrow on the right hand side of the screen.



Click on each button on the right hand side for further details.

Click Arrow to Continue **Return**

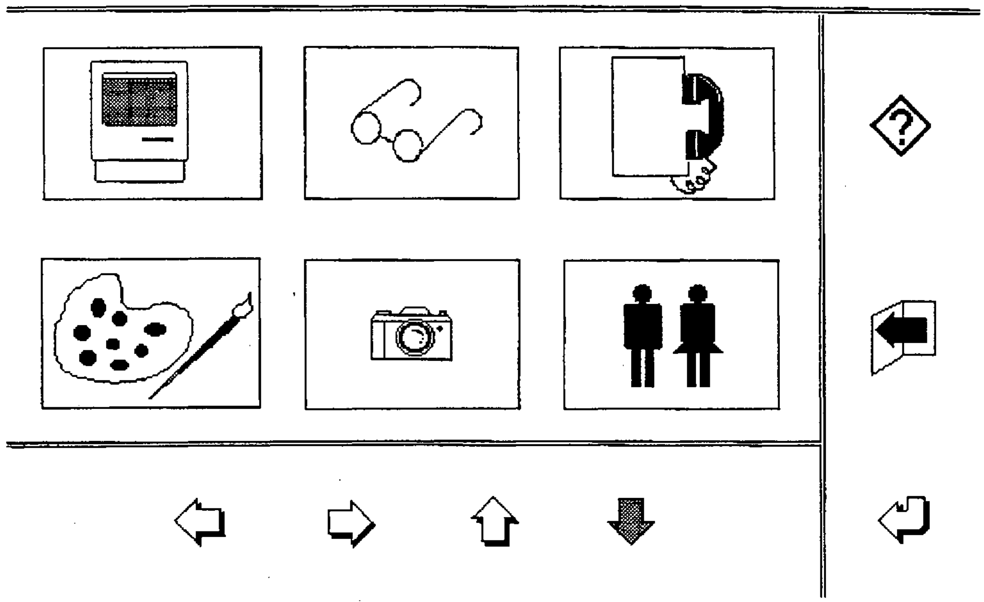
Instructions for Visiting Hopewell Mall

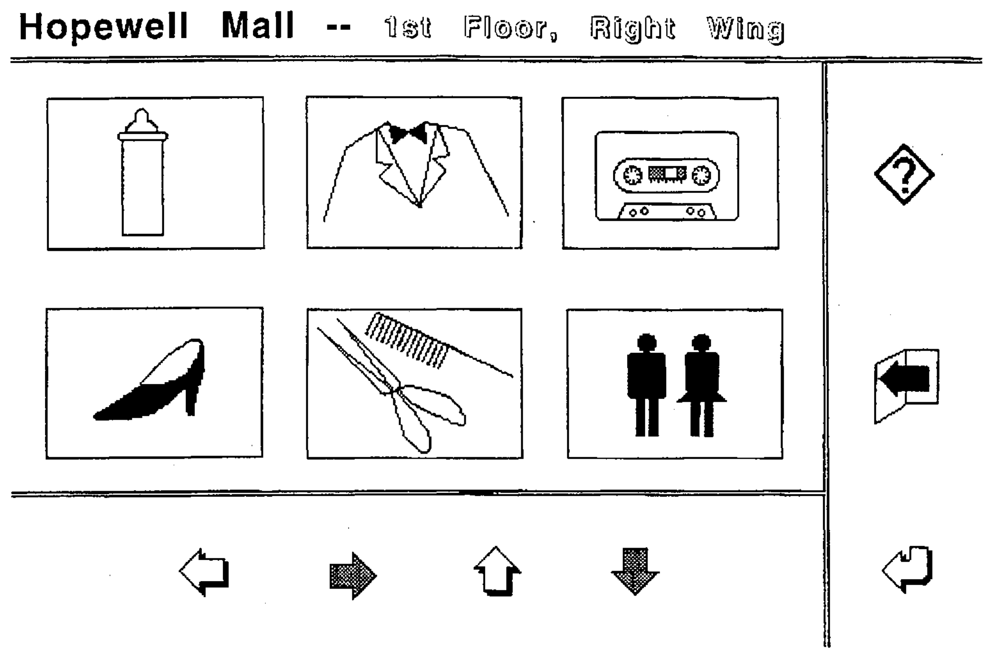
Now you have read all the information you need to know to visit this mall. Click on the following "Start" button to visit the mall. Have fun shopping Hopewell Mall!

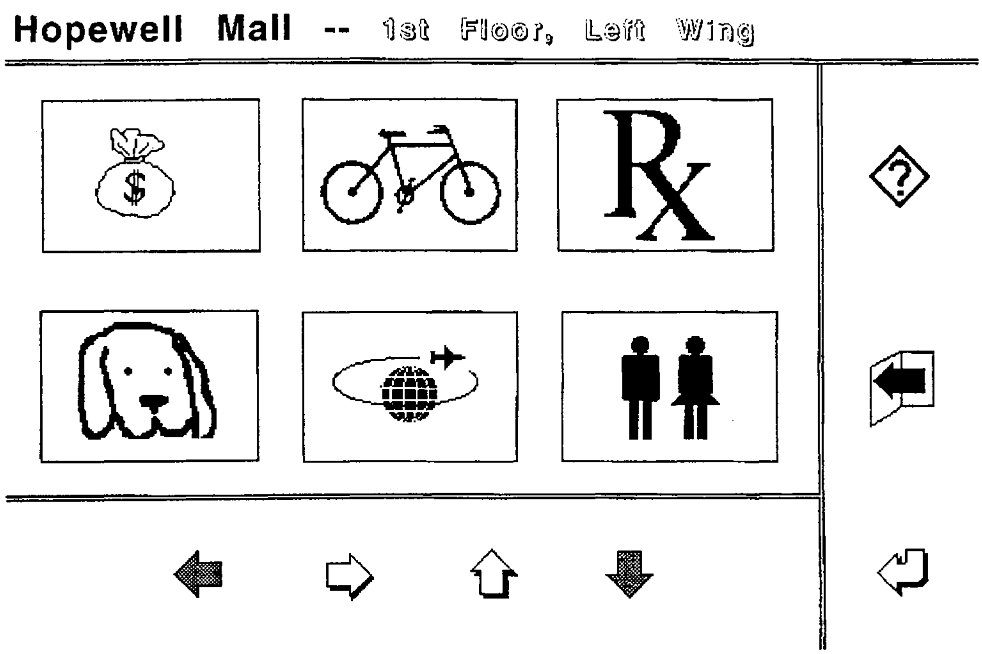
Start

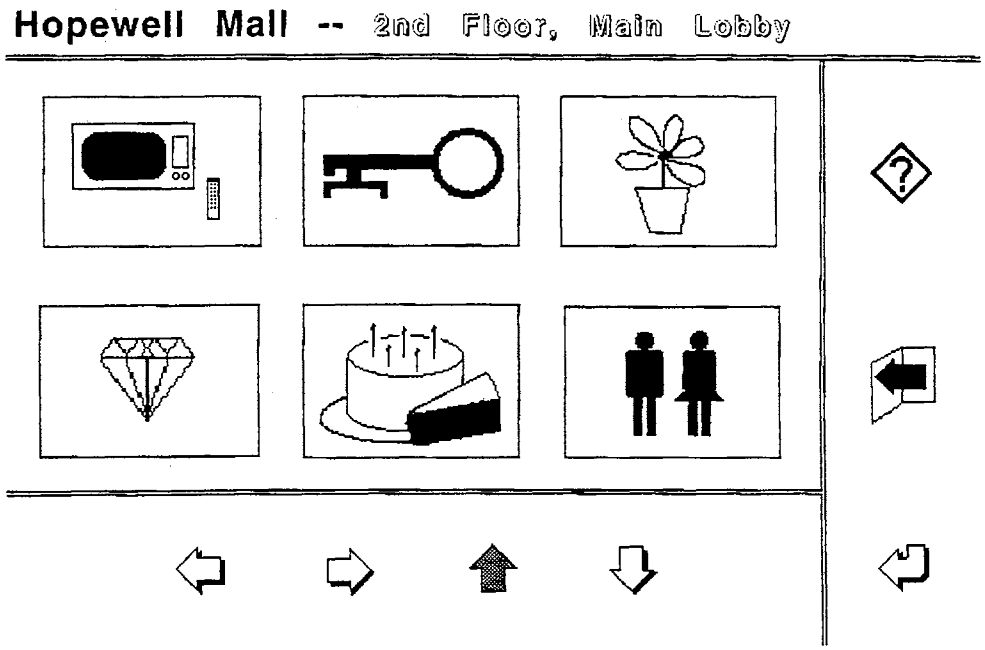
Return

Hopewell Mall -- 1st Floor, Main Lobby

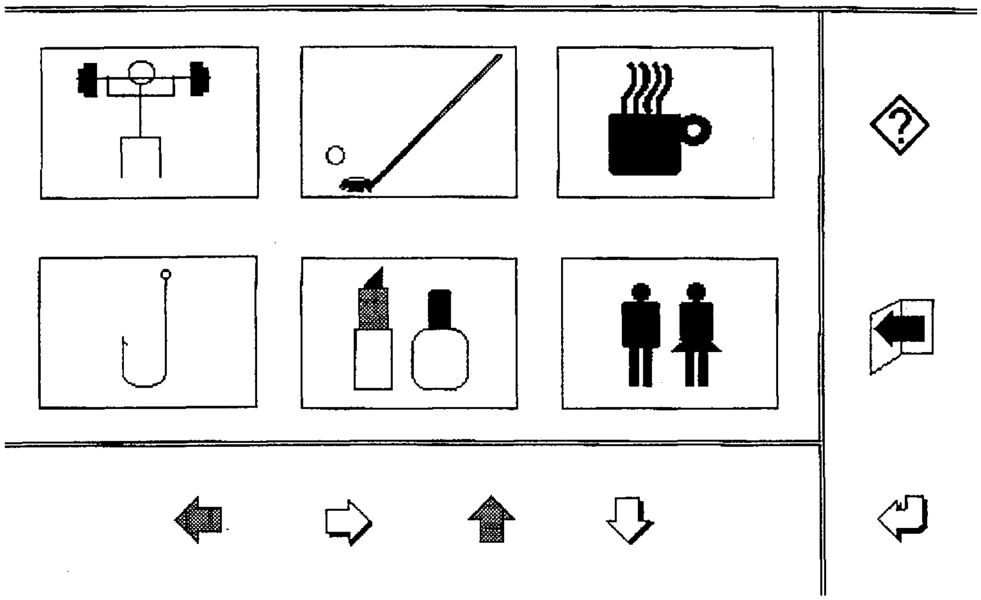


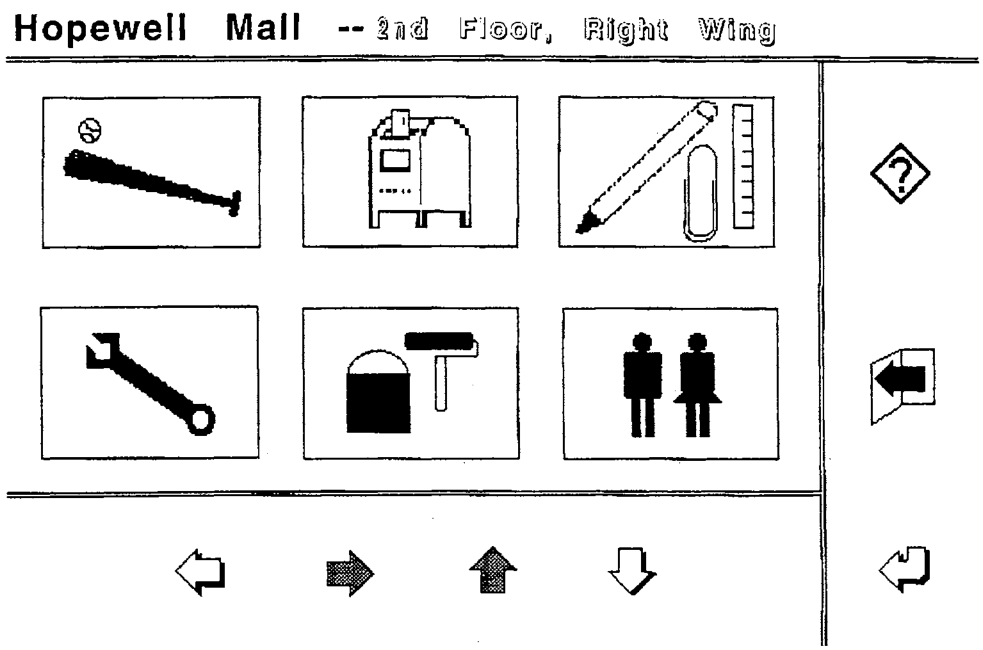

Hopewell Mall -- 1st Floor, Right Wing


Hopewell Mall -- 1st Floor, Left Wing


Hopewell Mall -- 2nd Floor, Main Lobby

Hopewell Mall -- 2nd Floor, Left Wing




Hopewell Mall -- 2nd Floor, Right Wing

Welcome to Hopewell Mall

(text version)

Introduction

The program you are going to use is to test how well its particular design can help you find information you need. The example used in this test is an "electronic" shopping mall. You are going to visit this mall very soon.

To perform this test, you first read through orientation information about instructions on visiting this mall.

Then you will be given some problems to solve. You solve them by using this program to find the answers.

When you are finished reading this screen, click on the arrow below to go to the next screen.

Click Arrow to Continue

Instructions for Visiting Hopewell Mall

Please carefully read through the instructions in the following screens before visiting the mall. These instructions will help you travel in this mall.

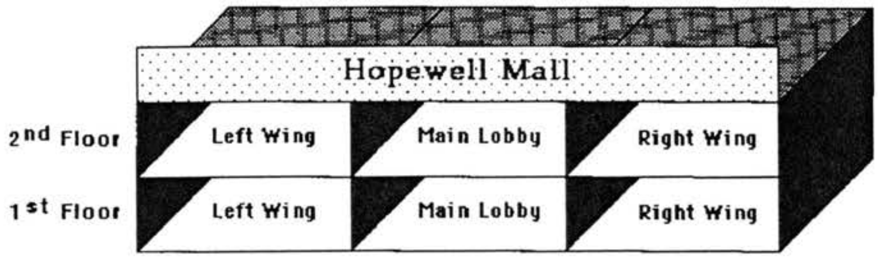
Click on the forward arrow at the bottom center of the screen to go to the next screen.

If you want to go back to the previous screen, click on the bent arrow at the bottom right-hand corner. This arrow appears on every card.

Click Arrow to Continue **Return**

Instructions for Visiting Hopewell Mall

Hopewell Mall consists of two floors. Each floor has three sections: the main lobby, the right wing, and the left wing as shown in the following three-dimensional diagram.

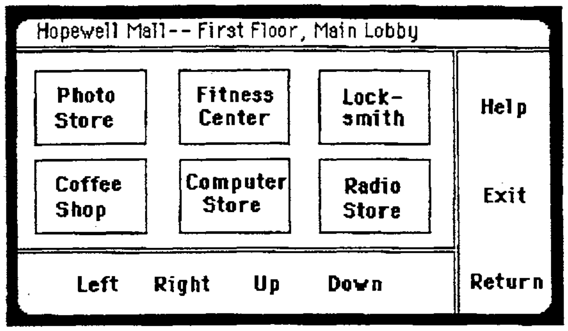


Click Arrow to Continue

Return

Instructions for Visiting Hopewell Mall

Each time, the screen displays only one section of the floor. For instance, the screen below shows the first floor of the main lobby.

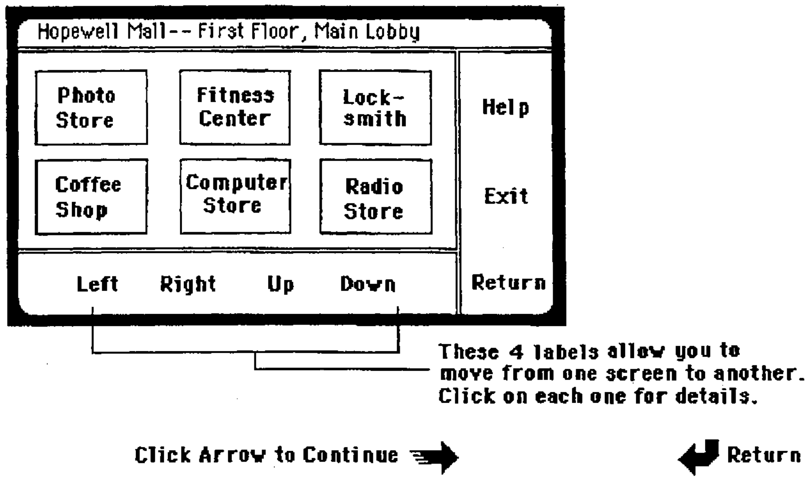


As shown in the above picture, each of the labels indicates a store.

Click Arrow to Continue ➡ ↩ **Return**

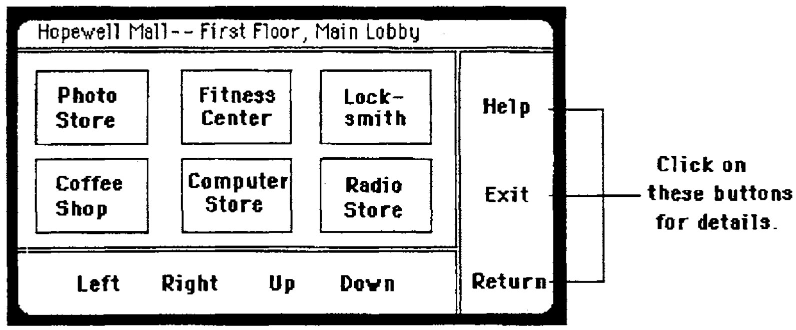
Instructions for Visiting Hopewell Mall

You may go around in this mall by using the arrows at the bottom center of the screen. Click on each arrow for further information.



Instructions for Visiting Hopewell Mall

Each screen also displays a Help label, an Exit label, a Return label on the right-hand side of the screen.



Click on each of the three labels for further details.

Click Arrow to Continue

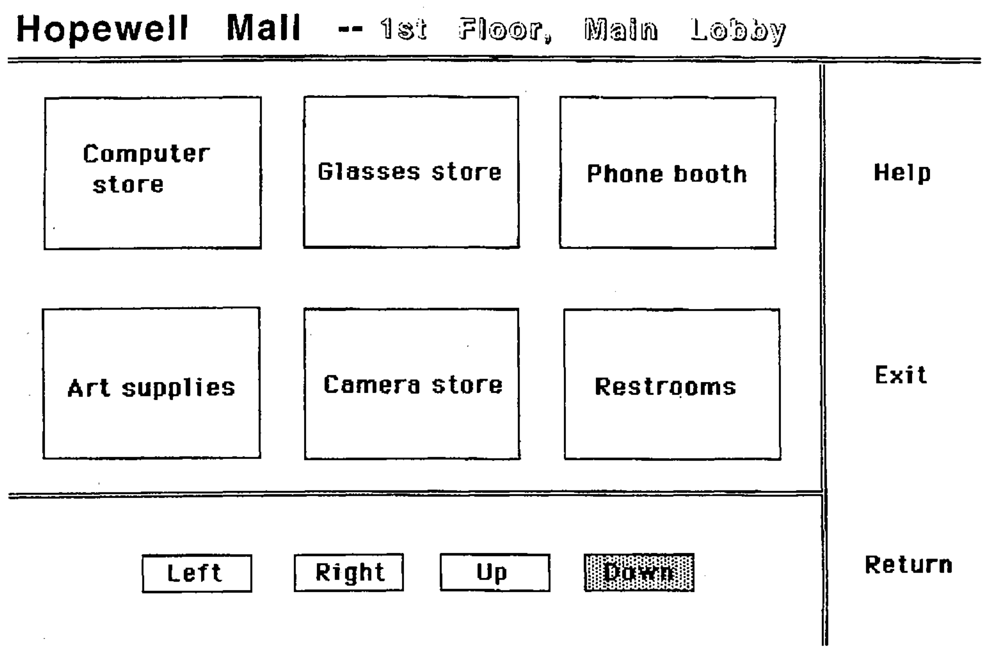
Return

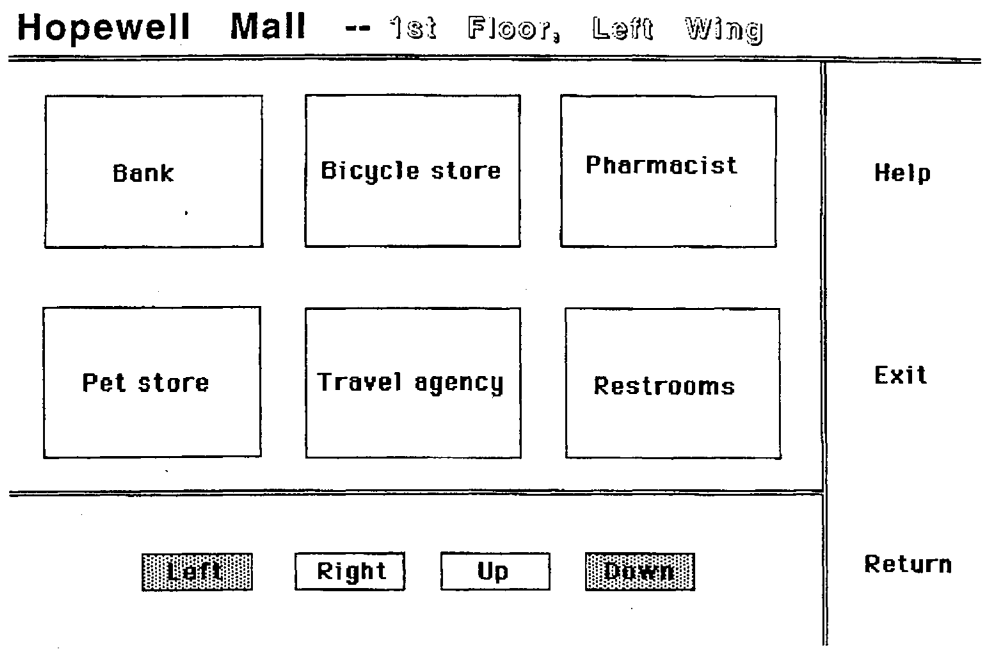
Instructions for Visiting Hopewell Mall

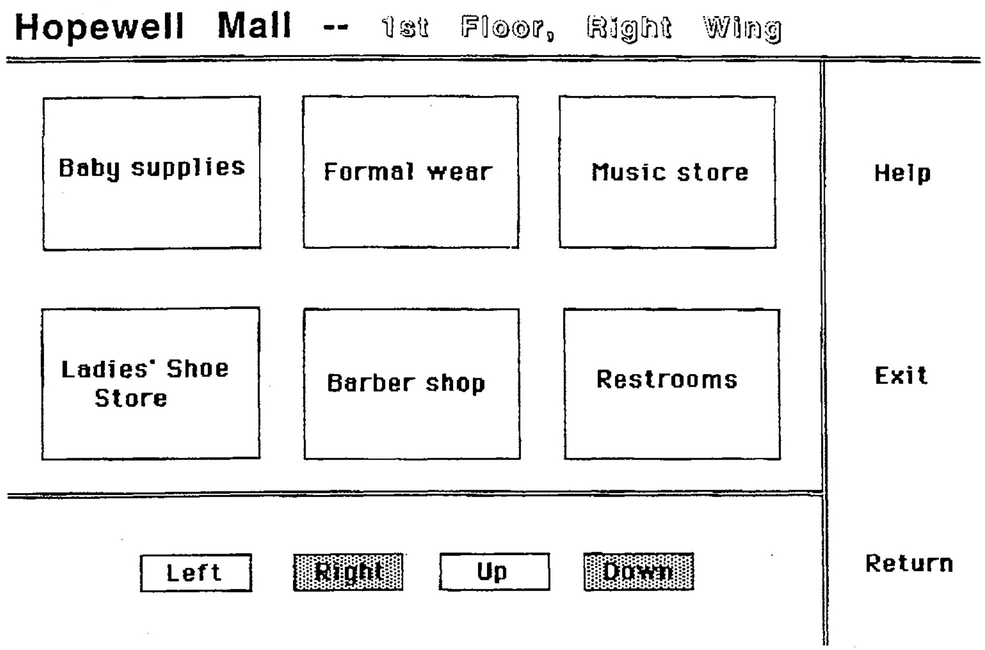
Now you have read all the information you need to know to visit this mall. Click on the following "Start" button to visit the mall. Have fun shopping Hopewell Mall!

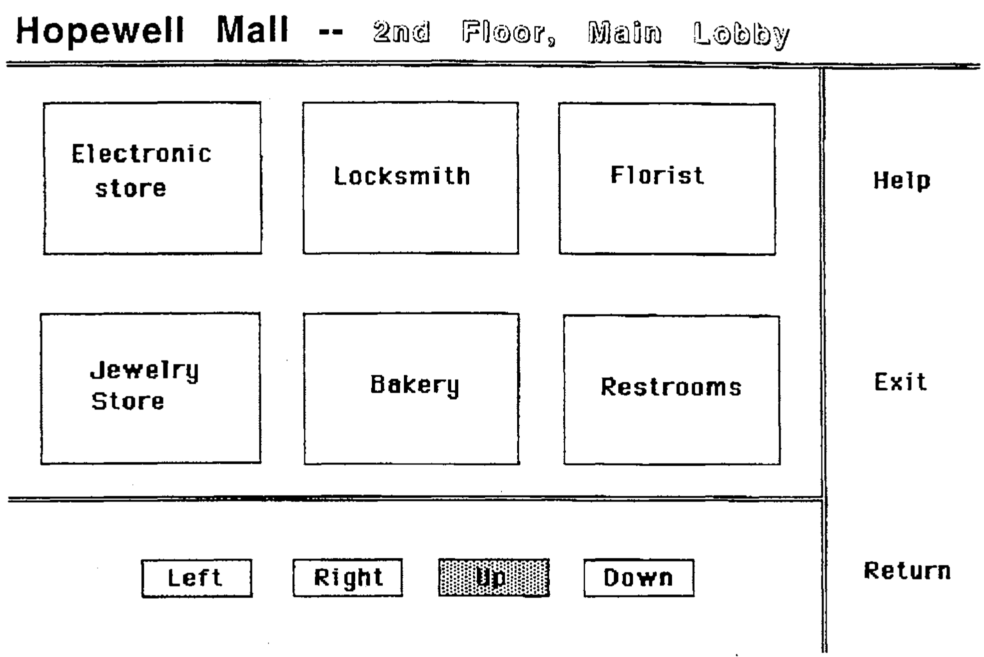
Start

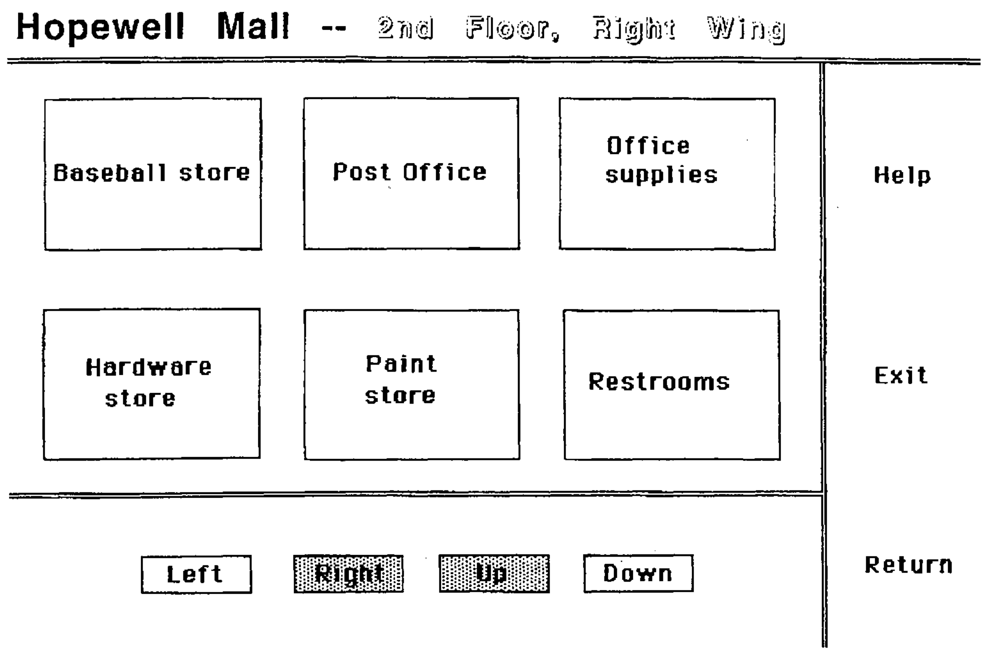
Return


Hopewell Mall -- 1st Floor, Main Lobby
Computer store
Glasses store
Phone booth
Help
Art supplies
Camera store
Restrooms
Exit
Left
Right
Up
Down
Return


Hopewell Mall -- 1st Floor, Left Wing
Bank
Bicycle store
Pharmacist
Help
Pet store
Travel agency
Restrooms
Exit
Left
Right
Up
Down
Return

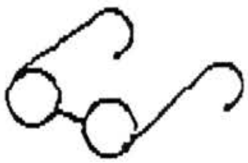
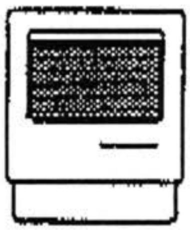
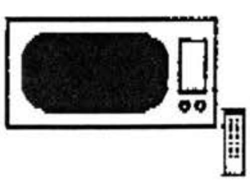
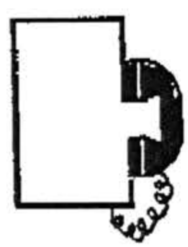

Hopewell Mall -- 1st Floor, Right Wing
Baby supplies
Formal wear
Music store
Help
Ladies' Shoe Store
Barber shop
Restrooms
Exit
Left
Right
Up
Down
Return

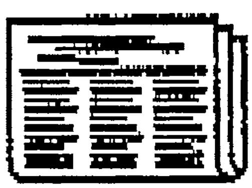
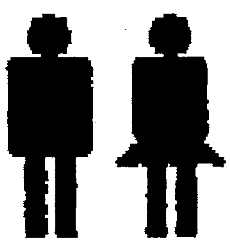
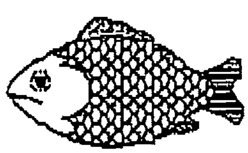
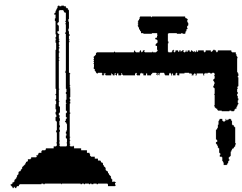
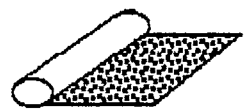

Hopewell Mall -- 2nd Floor, Main Lobby
Electronic store
Locksmith
Florist
Help
Jewelry Store
Bakery
Restrooms
Exit
Left
Right
Up
Down
Return

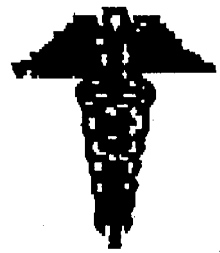
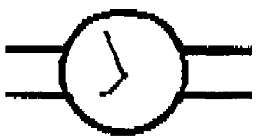
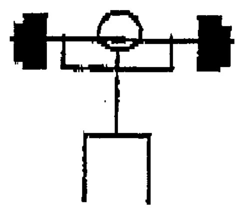
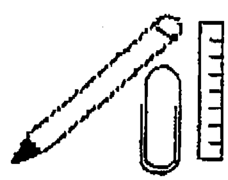

Hopewell Mall -- 2nd Floor, Right Wing
Baseball store
Post Office
Office supplies
Help
Hardware store
Paint store
Restrooms
Exit
Left
Right
Up
Down
Return

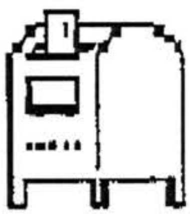
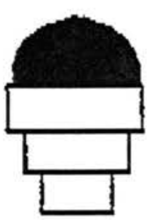
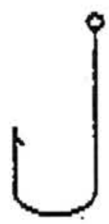
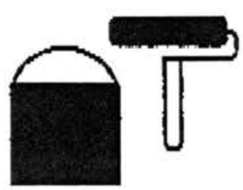
APPENDIX C: PERCENTAGES OF THE SUBJECTS GUESSED CORRECTLY THE INTENDED MEANINGS OF THE ICONS.

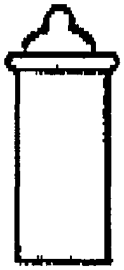
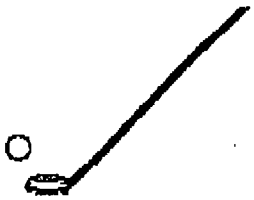
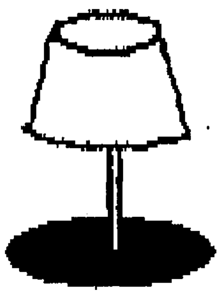
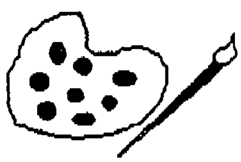
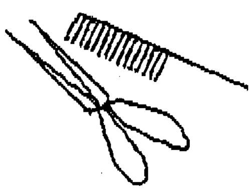
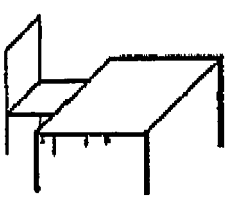
The icons with asterisks are the Icons chosen to design the hypertext program for the navigation test.

No.	Picture	Guess	No.	Picture	Guess
0.		bookstore (example)	6.		bank, ATM machine* (97.06%)
1.		glasses shop* (82.35%)	7.		bicycle, sporting goods* (88.24%)
2.		computer store, electronics store* (82.29%)	8.		music store* (94.11%)
3.		florist, garden store* (88.24%)	9.		pet shop* (97.08%)
4.		camera store* (97.06)	10.		travel agent, airline* (91.18%)
5.		TV store, electronics store* (91.18%)	11.		phone booth* (97.06%)

No.	Picture	Guess
12.		clothing store, men's wear * (88.24%)
13.		drug store* (91.18%)
14.		shoe store* (100%)
15.		newsstand, magazine stand (88.24%)
16.		restrooms* (97.62%)
17.		aquatic shop (76.47%)
18.		Cinema (61.76%)
19.		plumber, hardware store (58.82%)
20.		carpet (52.94%)
21.		tool shop* (82.35%)
22.		locksmith, key shop* (82.35%)
23.		Chinese restaurant (11.76%)

No.	Picture	Guess	No.	Picture	Guess
24.		bar (88.24%)	30.		money exchange (55.88%)
25.		trophy store (88.24%)	31.		doctor's office (76.47%)
26.		watch, jewelry store (82.35%)	32.		fitness center* (88.24%)
27.		restaurant, food court (82.35%)	33.		baseball supply* (91.18%)
28.		attorney's office (41.18%)	34.		drafting equipment store (29.18%)
29.		coffee shop* (94.11%)	35.		school or office supply* (91.18%)

No.	Picture	Guess
36.		fast food, snack shop (52.94%)
37.		bakery* (88.24%)
38.		mail box, post office* (100%)
39.		art gallery, paintings store* (94.11%)
40.		jewelry store* (97.06%)
41.		ice cream store (29.41%)
42.		cosmetics* (94.11%)
43.		luggage, suitcase store (88.24%)
44.		gun shop, pawn (88.24%)
45.		hiking supply, outdoors supply (76.47%)
46.		fishing store* (88.24%)
47.		paint shop* (94.11%)

No.	Picture	Guess
48.		baby supply store* (94.11%)
49.		golf supply store* (91.17%)
50.		lighting store (61.76%)
51.		art supplies* (94.11%)
52.		hair salon* (100%)
53.		furniture (4.06%)
54.		copy center (52.94%)

APPENDIX D: QUESTIONNAIRE FOR THE ICON-RECOGNITION TEST

Icon-Recognition Test

Thank you very much for helping me with my dissertation research. The purpose of this exercise is to investigate if the pictures I have designed are effective to represent the intended meanings. I will use these pictures to design an "electronic" shopping mall.

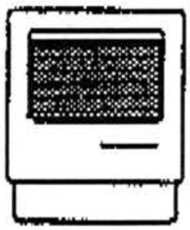
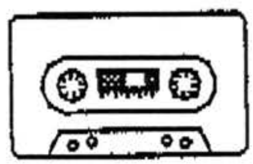
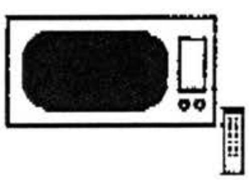
Instructions

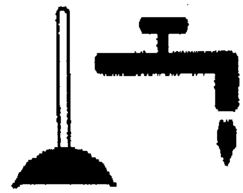
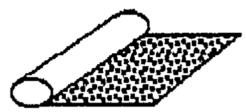
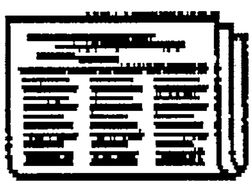
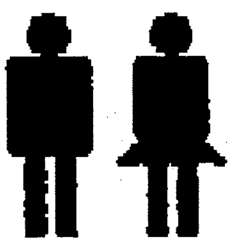
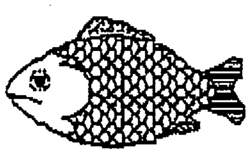
Imagine you were looking at a shopping mall directory that used these small pictures to represent the stores and facilities (e.g., restrooms). Try to guess what stores and facilities the pictures on the following pages represent and write down your guesses to the right of the graphics. I have done the first picture for you as an example.

If you have difficulty figuring out a particular icon, leave it blank and move on to the next one. I need to find out those icons that are not effective to represent their intended meanings.

You don't have a time limit to complete this exercise, but you should be able to finish it in less than 10 minutes. Have fun!

Thank you very much for you help again!!!

No.	Picture	Guess	No.	Picture	Guess
0.		bookstore	6.		
1.			7.		
2.			8.		
3.			9.		
4.			10.		
5.			11.		

No.	Picture	Guess	No.	Picture	Guess
12.			18.		
13.			19.		
14.			20.		
15.			21.		
16.			22.		
17.			23.		

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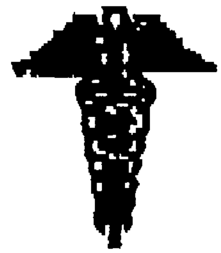
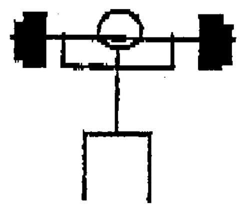
25.			31.		
26.			32.		
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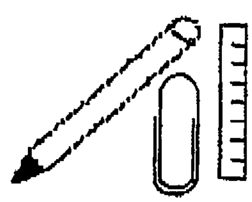
29.			35.		

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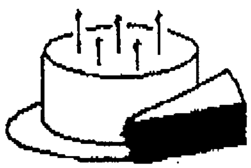
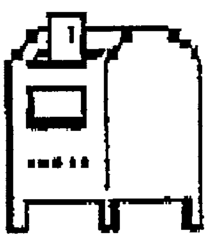
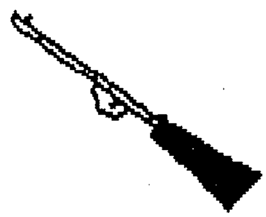
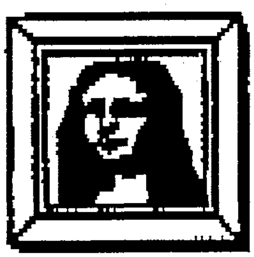
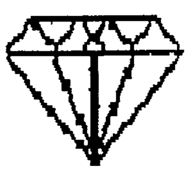
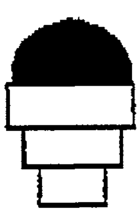
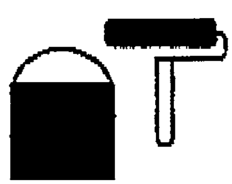
37.			43.		
38.			44.		
39.			45.		
40.			46.		
41.			47.		

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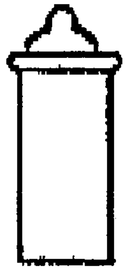
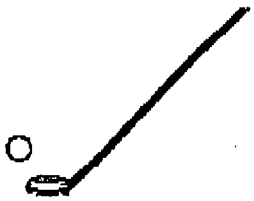
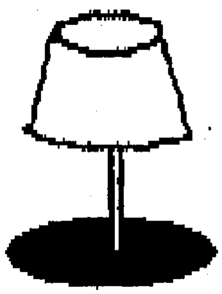
48.			54.		
49.					
50.					
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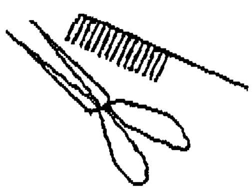
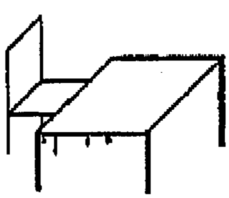
52.					
53.					

APPENDIX E: QUESTIONS FOR THE NAVIGATION TEST

Practice Questions

Problem	From	To
1	First floor, main lobby. Buy some art supplies.	Second floor, right wing. Buy a baseball bat.
2	Second floor, right wing. Buy a wrench.	First floor, main lobby. Buy some art supplies.

Exercise 1

Problem	From	To
1	First floor, main lobby. Repair your glasses.	First floor, right wing. Have a hair cut.
2	First floor, right wing. Buy some baby food.	First floor, left wing. Deposit a check.
3	First floor, left wing. Buy an airplane ticket.	Second floor, main lobby. Buy a plant.
4	Second floor, main lobby. Duplicate a key.	First floor, right wing. Buy a tuxedo.
5	First floor, right wing. Buy a music cassette.	Second floor, left wing. Buy a cup of coffee.
6	Second floor, left wing. Buy some fish bait.	First floor, main lobby. Buy a camera.

Exercise 2

Shopping list
1. Make a phone call (first floor, main lobby)
2. Repair your bicycle (First floor, left wing)
3. Buy golf balls (second floor, left wing)
4. Buy a TV (second floor, main lobby)
5. Mail a letter (Second floor, right wing)

Exercise 3

Repeat exercise 1.

2

VITA

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